Proceedings of the Fifth Joint Meeting of the Western International Forest Disease Work Conference and Western Forest Insect Work Conference

Breckenridge, Colorado
September 13 to 17, 1999

In Memory of Julie Weatherby, Dick Schmitz, and Bob Bega

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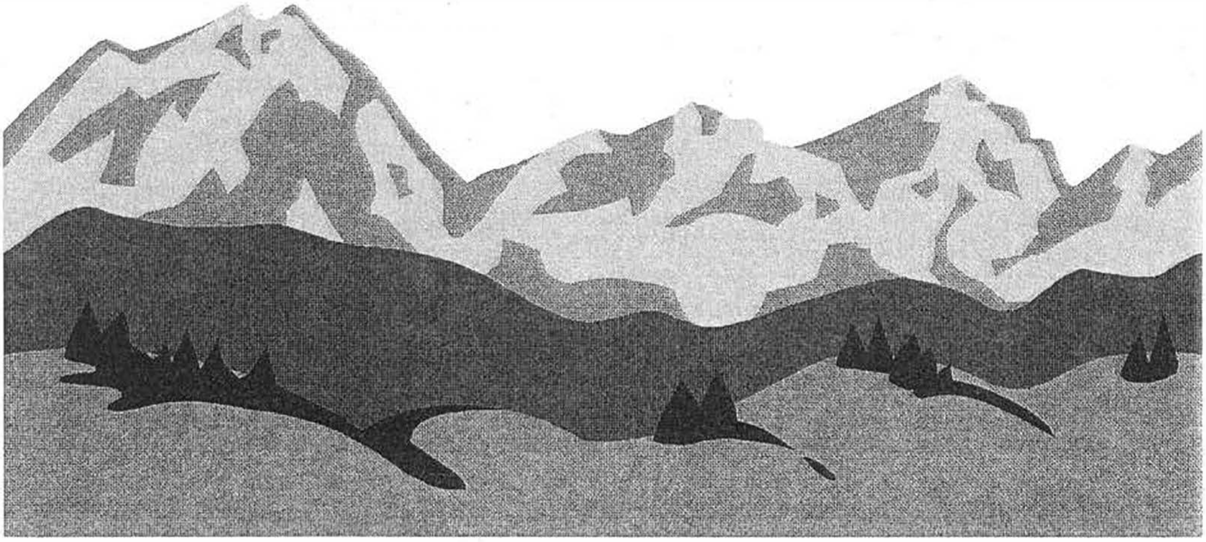

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Front Row: Pete Angwin, Jack Stein, Fred Baker, Jan Volney, Ann Lynch, Sue Hagle, Jane Taylor, Bob Edmonds, Deb Allen-Reid, Tom McGrath, Jaime Villa-Castillo, Paul Dunn, Eric Smith, Randy Molina. **Center Row**: Tom DeGomez, Ellen Goheen, Terry Rogers, Michelle Frank, John Hart, Mal Furniss, Don Goheen, David Beckman, Dan Omdal. **Back Row**: Mike Schomaker, Bill Jacobi, Evan Nebaker, Bob James, Will Littke, Jerry Beatty, Borys Tkacz, John Guyon, Matt Hansen, Brennan Ferguson, John Browning, Bob Cain, David Leatherman. Terry Shaw

Front Row: Leslie Chong, Andrea Tanaka, Julie Brooks, Guillermo Sanchez-Martinez, Joel McMillin, Carmelita Austin, Sheri Smith, Chris Hanlon, Doug Wulff, Karen Ripley, Susan Frankel, Beth Willhite, Brytten Nelsen, Bill Riel, Roger Burnside, Mark Schulz. **Center Row**: John Muir, Bob Gilbertson, Jose Negron, Jim Hoffman, Kristen Baker, Bill Woodruff, Les Koch, Don Owen, Lorraine Maclauchlan, Jan Huntsberger, Terry Shore, Ladd Livingston, John Pronos. **Back Row**: Gregg DeNitto, Bill Wallner, Russ Cozens, Jerry Carlson, Glen Stanosz, John Taylor, Barbara Palermo, John Schwandt, Allan Carroll, Stephen Nicholson, Dustin Wittwer, Tim Paine, Kier Klepzig, Alan Jones.

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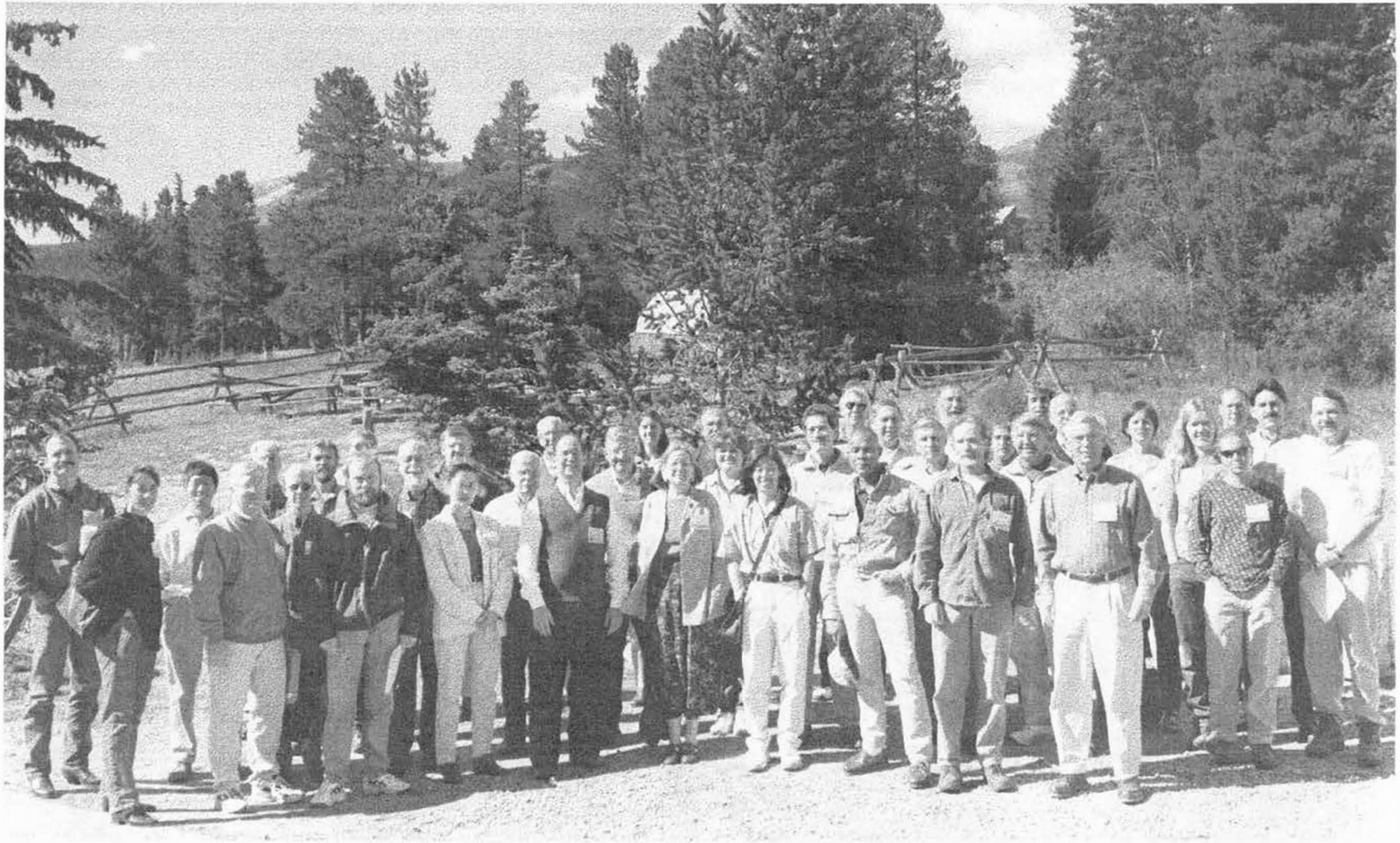


Front Row: Liz Herbertson, Steve Munson, Jeremy Allison, Eva Patterson, Bill Schaupp, Laura Merrill, Chris Niwa, Carroll Williams, Jesse Logan, Fred Stephen, Serena Herod. Center Row: Paul Hessburg, Shaoang Zhang, Roy Mask, Daniel Ryerson, Peter Lorio, John Moser, Keith Douce, Jeri Lyn Harris, Gary Daterman, Wayne Berisford, Roger Sandquist, Sue Bookout, Tom Eager. **Back Row**: Dave Johnson, Bob Averill, Jim Speer, Glenn Peterson, Kirsten Haberkern, Steve Cook, Mike Marsden, Mike McWilliams, Matt Cahir, Jeff Moore, Steve Kohler, Diana Six, Barbara Bentz, Jimmie Joe Honaker

PROGRAM

Monday, September 13, 1999

8:30am to 3:30pm	STDP Insect Management Committee Meeting
12:00 noon to 5:00pm	Western Nursery Pathologists Meeting
2:00pm to 8:00pm	Registration
6:00pm to 8:00pm	Social Mixer
5:00pm to 7:00pm	WFIWC Executive Meeting

Tuesday, September 14, 1999

7:00am to 6:00pm	Registration
7:00am to 8:30am	Dwarf Mistletoe Committee Meeting Breakfast
7:30am to 8:30am	WFIWC Business Meeting
8:30am to 9:00am	Welcome, Introductions, and Addresses *Dave Johnson, Tom Eager, and Fred Baker*
9:00am to 9:30am	Keynote Address - *Jim Hubbard*, Colorado State Forester
9:30am to 10:00am	Guest Speaker - *Martha Ketelle*, Forest Supervisor, White River National Forest
10:00am to 10:30am	Break
10:30am to 12:00 noon	Plenary Session: Biological Indicators of Forest Condition. Moderator: *Jaime Villa Castillo*
12:00 noon to 1:30pm	Hazard Tree Committee Meeting Luncheon
1:30pm to 3:00pm	Plenary Session: National Risk Mapping Effort *Joe Lewis*
3:00pm to 3:30pm	Break
3:30pm to 5:00pm	Plenary Session: Insects and Diseases in Western Forest Disturbance Regimes Moderator: *Ann Lynch*
5:00pm to 7:00pm	Cone and Seed Insect Committee Meeting
7:00pm to 9:00pm	Regional Research Project W-187 Meeting:

Wednesday, September 15, 1999

8:00am to 5:00pm	Field Trip
7:00pm to 9:00pm	Poster Session and Ice Cream Social

Thursday, September 16, 1999

7:00am to 8:30am	Disease Control Committee Meeting Breakfast
8:30am to 10:00am	Concurrent Workshops and Panels: Biological Control of Bark Beetles Moderator: *Ken Raffa* Defoliating Insects Moderator: *John Wenz* Effects of Prescribed Fire on Arthropods and Diseases Moderator: *Chris Niwa* Disturbance in the Rockies Moderator: *Ann Lynch*
10:00am to 10:30am	Break
10:30am to 12:00 noon	Concurrent Workshops and Panels: Special Papers Moderator: *Steve Seybold* Detecting Vegetative Change Using Remote Sensing Moderator: *Bill Krausmann* NEPA, Appeals and Litiation: Implications for Insect and Disease Management Moderator: *Ralph Their* Forest Health Analysis at the Broad Scale Moderator: *Sue Hagle*
12:00 noon to 1:30pm	Rust Committee Meeting Luncheon
1:30pm to 3:00pm	Concurrent Workshops and Panels: Nursery and Seed Orchard Workshop Moderator: *Bob James* Biocontrol of Noxious Weeds Moderators: *Nancy Sturdevant and Sandy Kegley* Historical Review of the Flattops Spruce Beetle Outbreak Moderator: *John Schmidt* Spatal Analysis: How can We Use It? Moderator: *Jose Negron* Special Papers Moderator: *John Guyon*

Thursday, September 16, 1999 continued

3:00pm to 3:30 pm	Break
3:30 pm to 5:00pm	Concurent Workshops and Panels: Nursery and Seed Orchard Workshop continued Moderator: *Bob James* Protocols for Forest Health Monitoring in Urban Areas Moderator: *Mary Ellen Dix* Alpine Fir Decline *Moderators: Tom Eager*, Pete Angwin Special Papers Moderator: *Rona Sturrock*
6:00 pm to 8:00pm	Evening Banquet
8:00pm to 9:00m	Entomology Founders Award Presentation *Mal Furniss*

Friday, September 17, 1999

7:00am to 8:30am	Root Disease Committee Meeting Breakfast
8:30am to 10:00am	Concurrent Workshops and Panels: Bark Beetle/Fungal Interactions Moderator: *Diana Six* Database and Modeling Technolgy Development Moderator: *Judy Adams* Mountain Pine Beetle: The Next Wave Moderator: *Joel McMillan* Special Papers Moderator: *Jim Hoffman*
10:00am to 10:30am	Break
10:30am to12:00 noon	Business Meetings of WIFDWC and WFIWC
12:00 noon	Conclude

WIFDWC Chairperson's Opening Remarks

Fred Baker,
Department of Forest Resources, Utah State University

My first duty as chair of the Western International Forest Disease Work Conference is to pay tribute to our members who have passed away during the past year. Bob Bega, Reed Miller, Dick Schmitz, and Julie Weatherby. Let's give a moment of silent tribute to these friends, colleagues, and members of our profession.

As chair, I am charged with addressing this group. It has also been pointed out to me that I should be brief. Although that is hard for a university professor in front of a group, I shall try to do both.

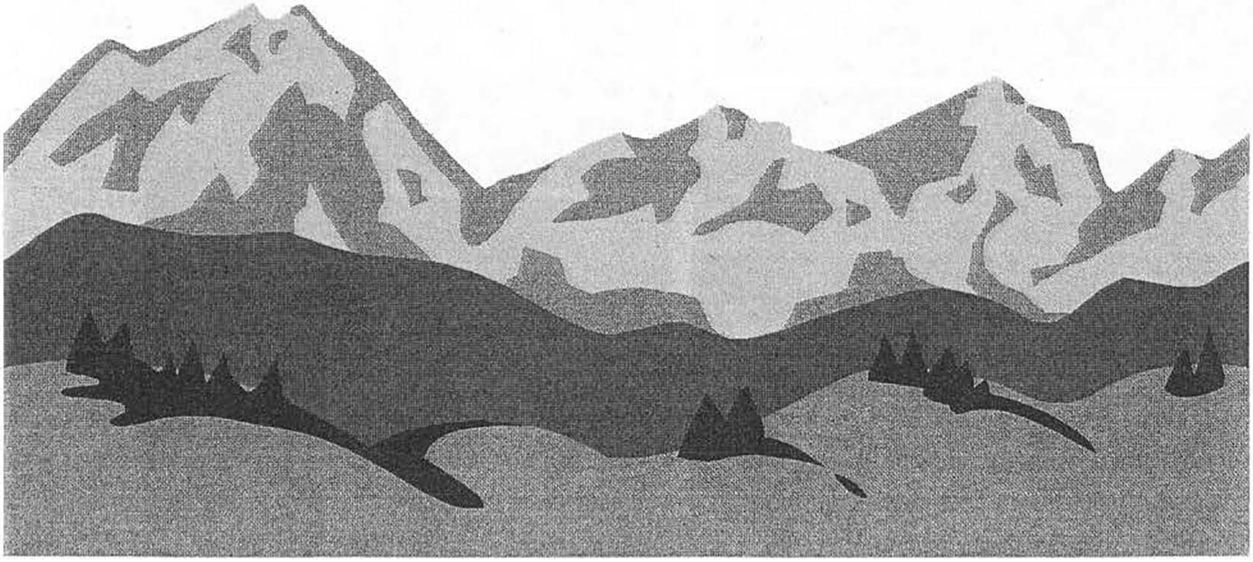
At our first joint meeting in Bend 10 years ago, there were 280 registered entomologists and pathologists. How many of you were there? (About 25-30%). At this meeting we expect 200. That represents change in our profession. Another change is the increasing reliance on technology. We communicate instantaneously by computer. Many of us registered for this meeting on the world wide web. Ten of us can all talk at once in a conference call to plan this meeting. Fax machines can deliver documents to us within minutes. You (and 120 others) can enroll and even get a college degree over the internet the (the virtual university) formally known as the Western Governor's University. Technology will continue to change our lives.

Societal changes also affect us. Population increases. More people are using our forests. Society changes the objectives for which we manage. Global trade introduces new pests. How does a society balance its resource management? What is the role of our profession in these social decisions?

As I look across this group, even though there are fewer of us, I see many young folks, and a few older folks. Our WIFDWC Secretary, who is younger than I am, has a few gray hairs. Resulting I am told from arranging this meeting. . Change is the constant in all of this, but that change is occurring at a greater pace than ever before. We must change the way we do business to affect the decisions that must be made in our forests, let alone survive. Many of the processes we use today involve the word collaborative: collaborative learning, collaborative planning are just two examples. Our effectiveness can increase if we can learn to use these tools. The alternative is to become less effective. Hardly a good strategy in these times.

This meeting represents a change in the way our groups meet. We can fall back and do the comfortable thing, or we can embrace this opportunity to "cross-pollinate" our experiences. Learning outside our fields and interests will be a necessary part of this changing future. Take advantage of the opportunities here to learn and to meet new people. Those with gray hair, seek out the youthful. You younger folks, learn about what the older folks are doing. Welcome to this joint meeting. Do your best to get the most out of it.

Plenary Sessions Workshops and Panels



PLENARY SESSION

Biological Indicators of Forest Condition

Moderator. Jaime Villa-Castillo. School of Forestry, Northern Arizona University, Flagstaff, AZ.

The Use of Mycorrhizal Fungi as Indicators of Forest Condition

Randy Molina, USDA Forest Service, Pacific Northwest Research Station, 3200 Jefferson Way,
Corvallis OR, 97331

Mycorrhizal fungi are mostly known for improving the mineral nutrition of host plants, but they also contribute significantly to many ecosystem processes. They are active in nutrient cycling, carbon sequestration, soil aggregation, and serve as critical links in forest foodwebs. Given their vast biological and functional diversity, they are good candidates for indicating ecosystem condition. For example, there has been a drastic decline in the fruiting of several species and genera of ectomycorrhizal fungi in Europe where high levels of pollution are thought to be causative agents. In regions such as the Pacific Northwest where pollution is less prevalent, many of the same genera that have declined in Europe continue as healthy populations. Thus, presence or absence of certain species of ectomycorrhizal fungi may be good indicators of pollution. Arbuscular mycorrhizal fungi have been shown to be good indicators of nitrogen eutrophication; high nitrogen inputs in polluted areas around the Los Angeles basin, for example, have caused shifts in the arbuscular fungal community which results in a shift from desirable chaparral communities to less desirable annual grasslands. An important first step in deciding the value and usefulness of a fungal indicator is developing a specific objective or need for the indicator. Looking for a fungal species that indicates a desirable rate of nitrogen mineralization differs from finding an indicator of healthy food web linkages. Mycorrhizal fungal communities also change in space and time, so these factors must also be considered when selecting a fungal indicator. Overall, the outlook is good for using mycorrhizal fungi as indicators of forest condition. The essential first steps in doing so are carefully crafting the objective need for the indicator, and then designing research that targets finding and selecting the appropriate species or guilds of fungal indicators to fill that need.

Fungi: Indicators of Ecosystems and Ecosystem Status

Geral I. McDonald
USDA Forest Service, Rocky Mountain Research Station, Moscow, Idaho

Introduction

Many soil-inhabiting fungi occur in forested ecosystems throughout the world. Some cause serious disease problems such as root and butt rot in everything from seedlings to mature trees and shrubs, while others are simple saprophytes. A close association with the soil environment and the host plants that integrate the below-ground and above-ground environments characterizes the life cycles of these fungi. Therefore, soil microbes may be useful indicators of ecosystems and their status. The genus *Armillaria* may be a particularly useful indicator. Species of *Armillaria* are ubiquitous in most forested ecosystems of both hemispheres. Some are pathogenic and others are beneficial saprophytes. Some species appear to be restricted to cold ecosystems while others seem restricted to warm ecosystems; whereas, other ecosystems support no *Armillaria*. Finally, the distribution of pathogenic species does not always coincide with the expression of disease. There are indications that where the saprophytic species occur they routinely form connections among most living and dead woody plants. This saprophytic microbial mass may reach 4 tons per hectare. If such features of the genus hold true, then its potential as an indicator of ecosystems and ecosystem status is genuine. This paper is a preliminary assessment of that potential.

Ecological Context

A method designed to place *Armillaria* plot data into a phytosociological definition of ecosystems was presented earlier (McDonald, 1998). This system grouped habitat types into potential vegetation groups. A recently published classification of North American vegetation (Brown et al., 1998) presented an opportunity to place these plot data into a continent-wide hierarchical scheme and connect ecosystem effects of disturbances caused by diseases to those caused by other agents such as fire (McDonald et al., in press). The potential vegetation groups were renamed as subseries. I will use the perspective afforded by the marriage of North American Biotic Communities (NABC) (Brown et al., 1998), subseries, and my catalog of random vegetation/*Armillaria* plots located in western North America to predict some general distributions of *Armillaria* species. We obtained a digital version of the NABC map (United States Environmental Protection Agency), cut it to the US western states, and overlaid state boundaries to display a subset of the 82 biotic communities mapped for North America (Figure 1).

Armillaria plot data collected within the Rocky Mountain Montane Conifer Forest Biotic Community were distributed into subseries (Figure 2) in order to predict the distribution of *Armillaria* species in North America (Figure 3). These predictions are based on published distribution maps (Morrison et al., 1985; Proffer et al., 1987; Dumas, 1988; Mallett, 1990; Blodgett and Worrall, 1992; Banik et al., 1995; Banik et al., 1996; Baumgartner and Rizzo, 1998). Also included are some of my unpublished data. Two northeastern species (*A. gemina* and *A. calvescens*) and two northwestern species (*A. nabsnona* and *A. cepistipes*) are not considered because of limited distributions.

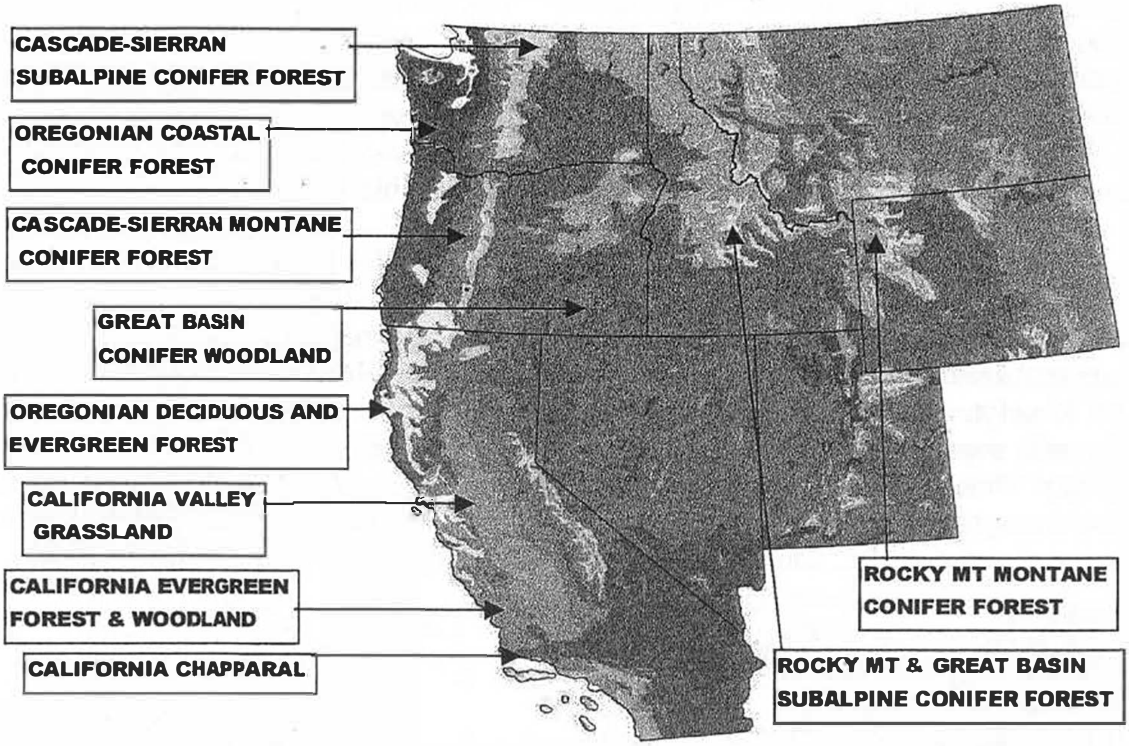
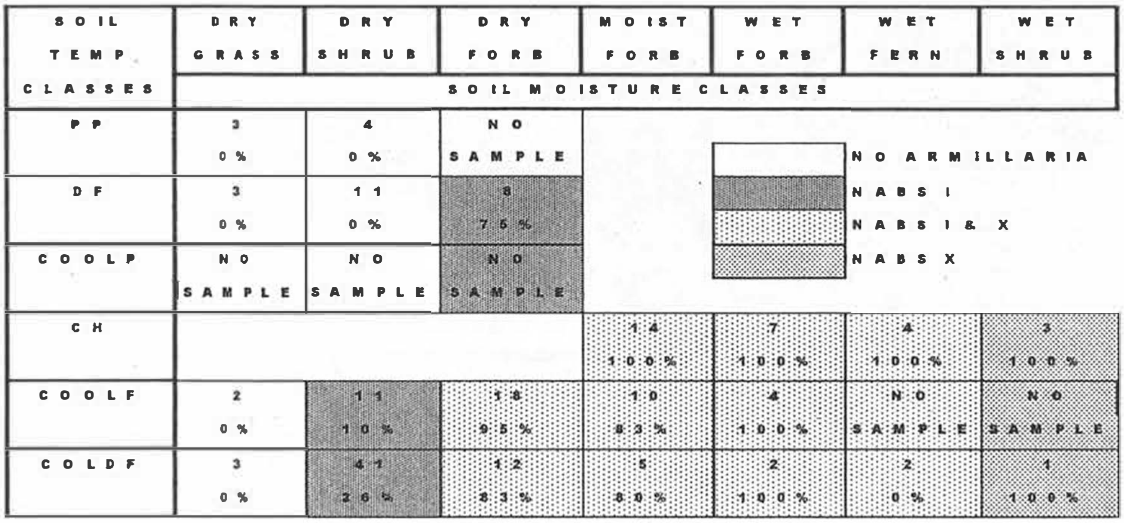

CASCADE-SIERRAN SUBALPINE CONIFER FOREST
OREGONIAN COASTAL CONIFER FOREST
CASCADE-SIERRAN MONTANE CONIFER FOREST
GREAT BASIN CONIFER WOODLAND
OREGONIAN DECIDUOUS AND EVERGREEN FOREST
CALIFORNIA VALLEY GRASSLAND
CALIFORNIA EVERGREEN FOREST & WOODLAND
CALIFORNIA CHAPPARAL
ROCKY MT MONTANE CONIFER FOREST
ROCKY MT & GREAT BASIN SUBALPINE CONIFER FOREST

Figure 1. Map highlighting the major forested North American Biotic Communities of the western United States.



SOIL TEMP CLASSES	DRY GRASS	DRY SHRUB	DRY FORB	MOIST FORB	WET FORB	WET FERN	WET SHRUB
	SOIL MOISTURE CLASSES						
PP	☐ 3 0%	☐ 4 0%	NO SAMPLE				
DF	☐ 3 0%	☐ 11 0%	▓ 8 75%				
COOLP	NO SAMPLE	NO SAMPLE	▓ NO SAMPLE				
CH				░ 14 100%	░ 7 100%	░ 4 100%	▒ 3 100%
COOLF	☐ 2 0%	▓ 11 10%	░ 18 95%	░ 10 83%	░ 4 100%	░ NO SAMPLE	▒ NO SAMPLE
COLDF	☐ 3 0%	▓ 41 26%	░ 12 83%	░ 5 80%	░ 2 100%	░ 2 0%	▒ 1 100%

☐	NO ARMILLARIA
▓	NABS I
░	NABS I & X
▒	NABS X

Figure 2. Distribution of *Amillaria* vegetative isolates collected from 0.014 ha plots within the Rocky Mountain Montane Conifer Forest Biotic Community to subseries (PP/Dry Grass is a subseries - see McDonald 1998 for complete explanation).

Cited distributions of the major species are generalizations, since basidiome production varies greatly by year and genet (McDonald et al., 1998) and published accounts are largely based on sampling for basidiomes. These accounts may not reflect the actual species distribution. The only reliable method for assessing distributions is the establishment of random plots and the collection of vegetative samples from a thorough search of a fixed area. To connect distributions to the biotic communities, each plot had associated plant distributions recorded. This has been completed only in the northern and central Rocky Mountains (McDonald, 1998). These data provide an anchor from which to interpret the published results (Figure 2).

The northern Rocky Mountains (2nd circle on upper left - Figure 3) contain a mixture of sites. Some of these sites fall into the DF/DRY FORB and COOLF/DRY SHRUB subseries where only *A. ostoyae* (O) was found. All DRY GRASS and most DRY SHRUB subseries did not support *Armillaria* (NA) (McDonald, unpublished data). However, most sites supported both NABS X and *A. ostoyae* (XO). Out of more than 1,000 genets delineated and identified so far (McDonald, unpublished data), only 11 belonged to other species (3 *A. nabsnona* and 8 *A. sinapina*). Thus, this region was characterized as XO. The coastal Pacific Northwest seems to support mainly *A. sinapina* and *A. ostoyae* (SO). *A. gallica* has been collected from two warm locations, Vancouver, BC, Canada (Morrison et al., 1985) and Corvallis, OR (McDonald, unpublished data). The same situation is true within the eastern SO region. *A. gallica* has been collected in relatively mild areas, as has *A. mellea* (Harrington and Rizzo, 1993). Collections from California are almost all *A. gallica* and *A. mellea* (GM) (Baumgartner and Rizzo, 1998). Other collections substantiate the GM (warm) – XO or SO (cool) dichotomy in that only *A. gallica* was collected from Nebraska (Kim et al., unpublished data) and Iowa (McDonald, unpublished data).

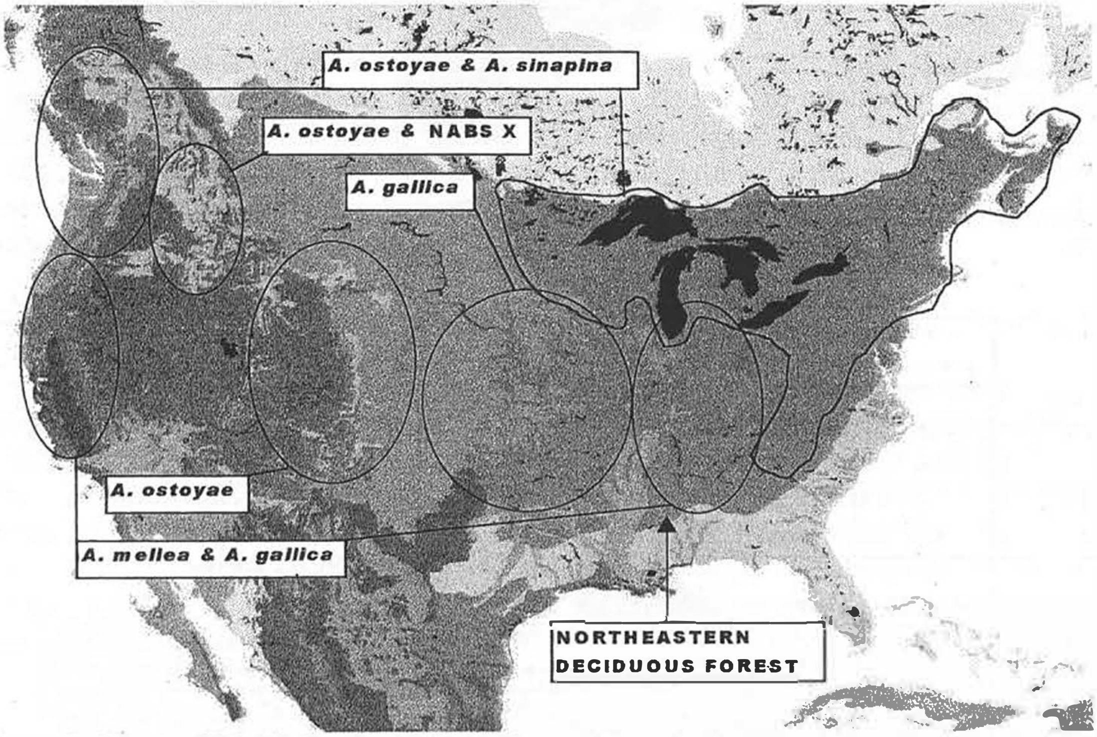


Figure 3. Expected North American distributions of five principal North American species of *Armillaria* (*A. ostoyae, A. mellea, A. sinapina, A. gallica* and NABS X)

The warm and cool pairs also seem to segregate along an environmental gradient. The dry ecosystems of Utah, Colorado, and New Mexico yielded only *A. ostoyae* (McDonald, 1998; Wu et al., 1996). Segregation of northern Rocky Mountain collections into wet and dry subseries (Figure 2) supports this trend (McDonald, unpublished data). Co-distribution of GM in California argues against a similar split, but a clear assessment is not possible because the appropriate random, area-based plots have not been installed outside the northern Rocky Mountains. When observing the distribution pattern based on data we do have (Figure 3), moisture and temperature influences on species distributions are readily apparent. *A. sinapina* seems adapted to cooler environments than NABS X, but both require more moisture than *A. ostoyae*. However, all three species seem to require relatively cool soils. Preliminary soil temperature data (McDonald unpublished data) collected at a depth of 50cm indicates that all three species occur when this soil temperature is between 5 and 10.5°C. Soil temperature of the warm-pair (GM) sites typically varies from 11 to 16°C (McDonald, unpublished data).

Based on the above discussion, I hypothesize the following general distributions of *Armillaria* within the North American Biotic Communities. Rocky Mountain Montane Conifer Forest will support XO in the north; O in the Black Hills, Utah, Colorado, and New Mexico and NA where the forests are dry. The Cascade-Sierran Subalpine Conifer Forest will support SO in the north and XO in the south. The Cascade-Sierran Montane Conifer Forest will support XO in the north and GM in the south. The Oregonian Coastal Conifer Forest will support SO in the north and possibly XO in the south. Oregonian Deciduous and Evergreen Forest will support G in the north; GM in the south; and NA where this biotic community is warm and dry. California Evergreen Forest will support GM on its wet and cool sites. California Chaparral and California Valley Grassland should be too warm and dry to support *Armillaria*. However, where the latter is irrigated M might become established in orchards (Rizzo et al., 1998). Most of the Great Basin Conifer Woodland (Pinyon Juniper) is typically too warm and dry to support *Armillaria*. Much of the Rocky Mountain and Great Basin Subalpine Conifer Forest is too cold and dry. The Northeastern Deciduous Forest Biotic Community (NDFBC) is a special case. The authors of the classification (Brown et al., 1998) state that a serious criticism of their classification was that the NDFBC was too inclusive. A separation might be made on the basis of the 10.5°C soil temperature at 50cm isotherm, which should correspond to the range of eastern white pine (Figure 3). This region (hand drawn area on Figure 3) might have northern SO and southern XO *Armillaria* distributions. Current data argues that the remaining NDFBC would segregate along an east/west moisture and or temperature gradient. So far, only G has been collected in the less wet western reaches of the NDFBC. Random, area-based sampling may show a similar dichotomy in California.

Indicators of Ecosystem Status

Evidence from the northern Rocky Mountains indicates that expression of root disease caused by O does not always coincide with the distribution of O (McDonald, 1991). This situation is very apparent where white pine blister rust has removed western white pine (Neuenschwander et al., 1999; McDonald et al., in press). The ecophysiological maladaptation hypothesis was developed to explain the observed behavior (McDonald, 1991). If this hypothesis if is correct, then patterns of native pest activity will indicate the balance between host genes and environment at specific sites. Thus, expression of *Armillaria* root rot across the landscape will indicate ecosystem imbalance such as in north Idaho were secondary seral and climax species replaced western white pine (McDonald et al., in press).

Conclusions

Thorough testing of the ideas presented in this paper will require establishment of a continent-wide plot network to obtain the vegetation, *Armillaria*, and site data necessary for validation. Collection of such data would require an extensive effort, but the potential rewards are great. Expected natural occurrences and behavior of *Armillaria* species could be mapped. We could judge if man-caused perturbations, such as irrigation and global warming, have or will cause changes in distribution or behavior of *Armillaria*. Continental estimates of biomass and respiration contributed by the various *Armillaria* species could be made. Better understanding of these aspects would increase our overall ability to interpret assessments of ecosystem status.

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Bark Beetles (Coleoptera: Scolytidae) as Indicators of Ecosystem Function and Forest Health

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Over the past decades, the public and forest resource managers have seen bark beetles from the utilitarian perspective. Concerns are usually associated with tree mortality, visual impact, and timber losses. As a result, several outbreak prediction models and control methods for the most aggressive bark beetle species have been attempted with variable success. Such attempts, although well intentioned, are not really design to manage the health of the forests in the context of ecosystem management.

We argue that viewing bark beetles as natural disturbance agents reflects societal values. As societal values evolve toward a biocentric approach, a small growing portion of the scientific community recognizes that bark beetles are important for ecosystem function, and forest health. We can see in the current literature a few references on bark beetles as gap creators, tree scavengers, and ecosystem engineers addressing the positive role of these organisms in creating habitat diversity, structural diversity, and maintaining the dynamics of ecosystem function. For instance, the impact of bark beetle created gaps on plant succession, or the impact of bark beetle created snags on animal diversity is now being recognized.

From the above arguments we suggest that bark beetles can be used as ecological indicators. Insects have already been proposed in the Santiago Declaration as indicators of forest health and vitality. Additionally, the US Forest Service Forest Health Management Program proposes insects as indicators of forest conditions; however, in both cases indicator measurements (%forest affected area) and methodological surveys (aerial) are still biased because they focus on the few aggressive insect species, on epidemic population levels, tree damage, and economic losses. Under this scenario the assumption is that endemic insect population levels ≈ healthy forests, whereas epidemic insect population levels ≈ unhealthy forests. Although true in some cases, this assumption is too broad to be applicable to the multiple objectives of ecosystem management and forest sustainability.

Our suggestion is that because bark beetles, and gaps and snags created by them, are part of forest biodiversity, bark beetle diversity must be considered as an indicator of biodiversity, forest health, and ecosystem function. Under the context of forest sustainability and forest health, the higher or lower abundance of key forest insects may be considered an undesirable situation.

PLENARY SESSION

Insects and Diseases in Western Forest Disturbance Regimes

Moderator: Ann Lynch

Opening Comments

Ann M. Lynch, USDA Forest Service, Rocky Mountain Research Station, Flagstaff AZ

This session was designed to cover a variety of biotic and abiotic disturbance agents, with an emphasis on disturbance ecology as influenced by interactions. A presentation on spruce and spruce-fir disturbance agents is included in order to take advantage of an unusual level of activity of disturbance agents in those types. In recent years there has been a blossoming of relevant research and of survey information technology that will enable exploration of insects and diseases as agents in disturbance ecology.

The session was also intended to serve as a spring board for the discussion session on Thursday, *Disturbance in the Rockies*

Prescribed Fire Effects on Incidence of Root Disease and Bark Beetle Attacks in Ponderosa Pine Stands.

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INTRODUCTION

Root diseases of ponderosa pine, and in particular black stain root disease (BSRD), has been associated with increasing losses in stands in the southern portion of the Malheur NF as well as several other National Forests in eastern Oregon and Washington and northeastern California. Black-stain and other root diseases concern resource managers because of the broad scale effects of tree mortality: a) on wildlife, especially related to big game winter range and hiding cover; b) the high value of stands managed for fiber production on a reduced land base; and c) the increased fuel loading and risk of wildfire. A survey near Burns, OR, in 1995 confirmed that BSRD was both widespread and affecting a substantial portion of ponderosa pine communities. In advanced stages the disease can be diagnosed by chipping into the base of a tree and looking for the distinctive staining. Positive detection in earlier stages requires extensive root excavation.

BSRD is caused by three varieties of *Leptographium wageneri*: var *wageneri* on pinyon pines, var. *ponderosum* on ponderosa and lodgepole pines and mountain hemlock, and var. *pseudotsugae* on Douglas-fir. In Douglas-fir several root-feeding beetles are responsible for disease spread and are favored by conditions associated with various disturbances (Witcosky et al. 1986a). Season of thinning has an influence since the freshness of available slash when vectors disperse, determines where they go and how successful they will be in building populations (Harrington et al. 1985, Witcosky et al. 1986b, Hansen et al. 1988).

Managers increasingly question how stand treatments affect the spread and impact of BSRD. In ponderosa pine, BSRD occurs both as individuals and as clusters of diseased trees. Disease progression is much slower in pine than in Douglas-fir. Understanding spatial distribution of the disease will help determine the relative importance of insect spread versus root-to-root spread. The difference between these modes of spread has important implications for stand management. The biology of insect vectors is key in timing precommercial thinning activities to minimize the spread of BSRD in Douglas-fir and recent data indicate this may be so in pine (Kliejunas and Otrosina 1998).

Less is known about BSRD in ponderosa pine than in Douglas-fir. Vectors have not been identified in pine. However, the spatial distribution of most diseased trees and the finding of conidiophores of the causal fungus, *Leptographium wagnerii* var. *ponderosum*, in the galleries of two bark beetle species (Goheen and Cobb 1978) suggest that insects play a pivotal role in the dispersal of BSRD in pine. Beetle trapping has shown that several potential vectors are attracted to synthetic host volatiles (Niwa and Thies, unpublished data) and are caught in significantly greater numbers in disturbed (burned or thinned) pine stands than in paired undisturbed areas (Otrosina and Ferrell, 1995; Niwa and Thies, unpublished data). The distribution of BSRD in widespread individual trees adds to the circumstantial evidence that insect vectoring, not root to root contact, is primarily responsible for spread of the disease in pine. Primary attraction of bark beetles to volatiles released by stressed host trees has been documented for numerous scolytid species (Borden 1974), therefore, disturbance caused by burning and other management activities is likely to make stands more attractive to potential vectors. Beetle flight generally occurs from late-spring to mid-summer (Daterman et al. 1965; Niwa and Thies, unpublished data; Peck et al. 1997), during and immediately after spring burning activity.

To pick the most viable option, managers need to know how the seasonal timing of prescribed burning will affect the future development of BSRD in the stand. The purpose of this communication is to present an overview and preliminary results from our study of the impact of the season-of-burn on incidence of root disease and bark beetle attacks in ponderosa pine stands. Additionally, by way of this communication we are inviting others to join us in the examination of additional components of the ecosystem on the same study plots.

METHODS

STUDY AREAS: The study was established in six stands of mixed-age ponderosa pine with scattered western junipers in the south end of the Blue Mountains near Burns, Oregon. Each stand was thinned in 1994 or 1995, designated for underburning, and surveyed for disease and found to have some trees with BSRD. Each stand will serve as a replicate of the study with all treatments represented within the stand. The stands are in three locations designated as Trout, Kidd Flat, and Driveway, with 1, 1, and 4 stands respectively. A general description of the stand locations and parameters follow:

Location Information:

Trout
- Aspect: W; Elevation: 5400 ft.; Precipitation: 15"/year; Lat/Long: 43° 48'N 118° 56'W
- Plant community: PIPO/CAGE, ponderosa pine/elk sedge
- Soil: Gravelly loam and clay loam, bedrock is hard basalt and andesite
- Stand age: 80 - 100 years with frequent individuals that are about 200 years

Kidd Flat
- Aspect: NE; Elevation: 5400 ft.; Precipitation: 20"/year; Lat/Long: 43° 47'N 118° 57'W
- Plant community: PIPO/SYOR ponderosa pine/mountain snowberry
- Soil: Loam to gravelly loam, bedrock is moderately hard rhyolite
- Stand age: 80 - 100 years with intermittent individuals that are about 200 years

Driveway
- Aspect: SW; Elevation: 5600 ft.; Precipitation: 15"/year; Lat/Long: 43° 53'N 118° 45'W
- Plant community: PIPO/FEID, ponderosa pine/Idaho fescue
- Soil: Gravelly loam and clay loam, bedrock is hard basalt and andesite
- stand age: 80 - 100 years with intermittent individuals of about 200 years

Preburn Stand Parameters:

Stand	BA (sq ft/ac)	Trees/ac	DBH (in)	Ht (ft)
Trout	77	103	11.0	46
Kidd Flat	72	78	10.1	40
Driveway 14	91	137	9.8	46
Driveway 17	79	86	11.4	47
Driveway 26	85	108	11.0	50
Driveway 28	83	91	12.8	54

TREATMENT PLOTS: Each stand was divided into three contiguous treatment plots similar in type, aspect, and slope and approximately 30-60 acres each. Plot boundaries were established along topographic features with consideration for control of the underburning. Three treatments (no burn, fall burn, and spring burn) were assigned randomly to the three plots in each stand. Underburning was planned to reduce fuel loading and stocking of regeneration. Plots were burned during mid-October of 1997 or mid-June of 1998. Due to fuel and weather conditions the spring burns were somewhat later than normal. All burns were carried out within the burn prescription and fairly represented operational burns given weather and fuel conditions. Because of the timing of the burns, at each examination all 18 plots will have developed without further disturbance for the same number of growing seasons.

DATA COLLECTION SUBPLOTS: Within each treatment plot, six 0.5-acre circular subplots were established to evaluate responses to the burns. Subplots were established after the plots were burned. Subplots were located at least 300 ft apart on areas that represented the average stand and burn conditions on the treatment plot. Areas with few ponderosa pine such as a rock outcropping or a thicket of mountain-mahogany were avoided. Each subplot center was located between two trees conveniently located for hanging an insect trap. Subplot centers were marked with a metal pin and mapped to facilitate relocation.

PRIMARY TREE DATA AND FIRST ORDER FIRE EFFECTS: On each subplot, standing conifers dead or alive (with the exception of junipers) greater than 3.0 inches diameter at breast height (DBH), were tagged. Each tree was evaluated twice in 1998 for the presence of green needles: just after the spring burn and again in the fall. In June 1999, tagged trees still without green needles were evaluated for the presence of root disease by chopping into the base of the tree and examining some roots at the base of the tree. In fall 1998, the end of the first growing season following the underburnings, the following data were collected from tagged trees (n = 5436): tree number, species, bark color (red or brown), condition (live/dead) shortly after the spring burn, condition at the time of the fall 1998 data collection, needle complement, top kill (insect), top damage (other than fire), total height, scorch height, lower height of green needles, base of live crown before fire, diameter breast height, diameter stump height. The following were collected on each quadrant of the tree: maximum height of charring, degree of charring at the base, consumption of litter, bark thickness at breast height, bark thickness at stump height. Bark thickness was measured for every fifth tree on the control subplots and on the burn subplots with bark that appeared fully scorched or consumed.

BEETLE DATA: Flight Trapping: Each treatment plot was monitored for lower bole and root feeding beetles using Lindgren traps baited with alpha-pinene and ethanol. Preburn – In spring 1997, traps were placed on each of the 18 treatment blocks to establish species and background populations of potential BSRD vectors. Postburn – In spring 1998, the subplots were established and a Lindgren trap was suspended from a rope strung between two trees at each subplot center. Insect captures were collected every two weeks from June through August in 1998 and 1999. Bole Attacks: Attacks by *Dendroctonus valens* and other *Dendroctonus* spp. (we avoided chopping into live trees and so did not differentiate between mountain pine beetle and western pine beetle) were counted in October 1998 and again in October 1999. Attacks were recorded as new, old, or pitch out in each tree quadrant. Wood borer attacks and woodpecker activity were also recorded. A preliminary analysis was done on the 1998 data to detect differences between spring and fall burns but only using the counts from the uphill and downhill quadrants.

OTHER STUDY EMPHASIS AREAS: In addition to examining relationships between fire, insects, root disease, and potential insect vectors of root disease, studies have been initiated on the treatment plots to examine other emphasis areas: primary fire effects, understory vegetation, ectomycorrhizal fungi, post-fire ascomycetes, duff consumption, soil and litter arthropods, nutrient cycling and decomposition, distribution of fungivorous soil arthropods, and lichen survival. In addition to the authors, collaborative studies are being conducted with other investigators on the same treatment plots: Kei Fujimura, Emilie Grossmann, Charlie Johnson, Andy Moldenke, Jane Smith, Roger Rosentreter, Kevin Ryan, and Nancy Weber.

PRELIMINARY RESULTS

The data presented at this time should be regarded as preliminary. We have completed our data collections and some of the data analysis from 1998 but the data from 1999 is being processed.

CAUSE OF MORTALITY FOLLOWING BURN: Given as a percentage of tagged trees:

Treatment	BSRD*	Annosus*	Scorch**	Unknown
Control	0.6	0.3	0	1.5
Fall	5.7	0.6	25.1	0.1
Spring	4.7	1.2	8.6	0.1

* Mortality is likely a result of trees, already stressed by root disease, not withstanding the additional stress resulting from scorch.
** Trees killed by scorch tended to be the smaller trees on each treatment plot. Of the trees with only a partially scorched crown186 died later, apparently from basal charing. Of the trees with 100% crown scorch, 50 were alive and appeared to be doing well at the end of the second growing season.

LICHEN SPECIES ON TREATMENT PLOTS:
Ponderosa pine*
Bryoria fremontii: most common
Bryoria fuscescens: present but not common
Nodobryoria abbreviata - common
Letharia columbiana - common
Letharia vulpina - common
Douglas-fir*
Hypogymnia imshaugii - found on one Douglas-fir
*The subplots contained 5435 ponderosa pine and 1 Douglas-fir. The only other conifers present on the subplots were western juniper.

SCOLYTIDAE CAUGHT IN LINDGREN TRAPS: Nine species of possible BSRD vectors were captured: *Hylurgops porosus, Hylurgops reticulatus, Hylurgops subcostulatus, Hylastes macer, Hylastes nigrinus, Hylastes ruber, Hylastes longicollis, Hylastes gracilis, and Dendroctonus valens.*

BOLE ATTACKS BY BARK BEETLES:
Dendroctonus valens: Treatment means ranged from 2 - 15 percent of trees attacked. There was a significant difference between the number of trees attacked on the burned plots compared to the unburned plots.
Other *Dendroctonus* spp.: Treatment means ranged from 2 - 5 percent of trees attacked. There was no significant difference between the number of trees attacked on the burned plots compared to the unburned plots.

PRELIMINARY TAKE HOME MESSAGES AND OBSERVATIONS (as of fall 1999):
Note: these observations have not been validated by statistical analysis.

- There is little relationship between crown scorch and blackening of the tree bark and tree mortality.
- There is a close correlation with fire-caused reduction of bark thickness at the base of the tree and tree mortality.

- There were a relative few species of lichen found on the subplots. Although there was abundant crown and basal scorch on the trees there appears to have been little loss of viable lichen biomass as result of the burns.
- Of the dead trees where a root disease was identified, most trees with BSRD died after the fire, most trees with annosus root disease had died before the fire.
- All species of root feeding beetles were captured in greater abundance on the burned plots than in the unburned plots.
- *Dendroctonus valens* was more abundant in burned than unburned plots, both for bole attacks and flight trapping.
- Bole attacks by other *Dendroctonus* species were less frequent and did not show differences between treatments.

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Current Disturbances in Spruce-Fir Forests

Michelle M. Frank, USDA Forest Service, Region 2 Forest Health Management, Lakewood, CO

As you know, the spruce-fir cover type occurs throughout much of the West. In Colorado, it is a dominant cover type. Much of the spruce-fir cover type here is mature, and is considered to be declining in growth and vigor.

It can be found under many different management prescriptions: recreation, such as ski areas and hiking trails; scenic corridors; wilderness and roadless areas; National Parks and Monuments, as well as in the urban/wildland interface.

This morning, you heard Forest Supervisor Martha Ketelle talk about the Flattops spruce beetle outbreak on the White River National Forest. This outbreak started with scattered blowdown in June of 1939. When it was all said and done, 4.3 billion board feet of spruce and lodgepole pine were dead by 1954. Standing dead trees were still being salvaged from this outbreak area on the White River N. F. in 1998 when house logs were removed by helicopter.

We know that ecosystems change. They change barely noticed over decades or change very quickly. Trees, stands, and landscapes adjust to new conditions created by disturbances. Individual trees die and smaller ones take advantage of the new conditions of light, moisture, and nutrients to fill the space. On October 25, 1997 an unusual wind event occurred in Colorado. Winds in excess of 120 miles per hour were funneled westward over the Continental Divide, toppling close to 20,000 acres of forest on the Routt National Forest. It looked as if the trees had been combed flat. Approximately 12,000 acres of downed trees are in the Mt. Zirkel Wilderness Area and another 8,000 outside of the Wilderness. These areas are experiencing continued unraveling of stand edges. It is estimated that less drastic effects from this windstorm encompassed an additional 100,000 acres and that this area is of greater concern today than previously thought.

Work is currently underway looking at spruce beetle population build up in the main blowdown, as well as in the areas of scattered blowdown. Preliminary information from surveys indicates large numbers of adult beetles ready to fly in the spring of 2000. Activities being undertaken include the production of 3 Environmental Impact Statements, salvage of dead timber, monitoring of soils, streams, wildlife and fish habitat, and monitoring of the spruce beetle population.

Colorado isn't the only state experiencing tree mortality due to spruce beetle. On the Dixie and Manti-La Sal National Forests in Utah, thousands of spruce trees have died over the last several years. Region 3 is experiencing spruce beetle population increases and standing tree mortality in the Pinaleno Mountains of Arizona. Though this latter area is only 2,200 acres in size, it has great importance because it is the home range of the Mt. Graham Red Squirrel.

Switching gears from bark beetles to defoliators, *Nepitia janetae*, a geometrid moth, is causing sever defoliation of spruce in the Pinaleno and White Mountains of Arizona. These outbreaks are occurring at elevations above 10,000 feet. This insect has an unusual life cycle in that the been extreme and impacts are unknown at this time. It is assumed that impacts will be greater in mature stands.

Spruce aphid is another fall and winter defoliator of spruce trees in the Southwest. It is probable that this insect is exotic to this area. It was first reported in the southwest in ornamental plantings in Santa Fe, New Mexico and in the White Mountains of Arizona in 1988. This insect has been a sporadic defoliator of spruce in the southwest since that time. The most spectacular outbreak attributed to this insect occurred in the winter of 199-1996 in the White Mountains of AZ. All size classes of spruce were affected. Defoliation was heaviest at elevations where Engelmann spruce occurs mixed with Douglas-fir, white fir, subalpine fir, and ponderosa pine. Little or no defoliation has been reported for the areas of "pure" spruce, where *Nepitia* is found.

Subalpine fir mortality attributed to a complex of insect and disease factors has been observed throughout the host type in the Interior West. The Intermountain Region experienced the mortality of about 150,000 trees in the 1997-1998 season. The Northern Region lost about 60,000 trees in 1995 and the Rocky Mountain Region also experienced high mortality levels (480,000 trees) during the same time periods.

Balsam woolly adelgid is also a concern for Idaho. Tree mortality is being experienced over large areas, including those already affected by root disease and bark beetles.

There are many insects and diseases currently at work in the spruce-fir forests of the West. They are an integral part of the disturbance processes, which have shaped these forests over time. The short-term changes are dramatic and substantial. These disturbances become problematic when they threaten human values. Assessing and deciding among options where there is disagreement about the values at risk is very challenging.

Some disturbances cannot be controlled; others can be managed, while still others can be manipulated. Where we can influence or control expected disturbances, and where we choose to do so for specific reasons, actions taken are more successful when done BEFORE a major event occurs. For this to happen, we need a better understanding of why some of these changes are taking place, and how to deal with them.

A Dendrochronologic Record of Pandora Moth Outbreaks in Central Oregon

James H. Speer, University of Tennessee

The past timing and intensity of pandora moth defoliation was reconstructed using dendrochronological techniques. Pandora moth leaves a distinctive ring-width signature that is easily identifiable. The growth for the first year of the signature was half the normal ring-width, with narrow latewood. The following two years produced extremely narrow rings, with the entire suppression lasting from 4 to 18 years.

Twenty-two individual outbreaks were reconstructed from a 620-year-long chronology. Pandora moth outbreaks were episodic on individual sites, with a return interval of 9 to 156 years. On the regional scale of south central Oregon, outbreaks demonstrated a 37-year periodicity. On average pandora moth defoliation caused a 20% mean periodic growth reduction in defoliated ponderosa pine trees. Spread maps of the first year that sites demonstrated suppression were plotted revealed an apparent annual spread of the outbreaks. Examination of a fire history on one pandora moth outbreak site suggested that pandora moth outbreaks delay fire by interrupting the needle fall needed for fire spread. Superposed epoch analysis showed that the year that the outbreak was first recorded was significantly dry and the fourth year prior was significantly wet. Therefore, climate may be a triggering factor in pandora moth outbreaks.

Western Spruce Budworm and Climate

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Growth reduction due to insect defoliation is often detectable in tree radial growth rings, and we use this signal to reconstruct the timing, temporal variability, and spatial variability of past outbreaks, and interactions with other disturbance agents. Over the years, we have reconstructed western spruce budworm and some Douglas-fir tussock moth outbreak histories in the Colorado Front Range, southern Colorado, northern and southern New Mexico, and the Oregon Blue Mountains. These reconstructions validate well against known tree growth response patterns and documented outbreak histories in modern times. This work allows us to describe the temporal and spatial disturbance ecology of the defoliators at landscape and Regional scales.

The origiinal western spruce budworm chronologies from northern New Mexico showed a strong association between budworm outbreaks and precipitation. This led us to look at all the available data and explore possible associations between western spruce budworm and climate. All of the budworm series showed patterns of cyclicity and synchrony, two important issues in the study of insect population dynamics. We investigated the association of climatic variations and western spruce budworm population fluctuations, looking for evidence that climatic cycles are one of the causes of periodicity and synchrony in the budworm dynamics.

Comparisons of multi-century reconstructions showed considerable synchrony of outbreaks among stand within regions, and a remarkably consistent, positive correspondence between budworm population fluctuations and moisture levels. The pattern of association between budworm activity and periods of increased moisture was consistent in both Oregon and New Mexico, despite differences in frequency of wet and drought episodes between the two regions. In Oregon, the budworm chronology closely tracked the PDSI precipitation reconstruction, even when the precipitation cycle changed frequency. That is remarkably strong evidence that climate patterns affect budworm outbreak patterns. It doesn't show, one way or the other, if this is a direct or indirect effect.

Cross correlation functions of pairwise comparisons of budworm and precipitation are of low to moderate significance, statistically, but show a consistent correspondence between PDSI and budworm population maxima and minima. The PDSI cycle tends to lead the budworm populations (negative lags) with significant correlations, especially in New Mexico. This suggests that the forest or budworm system follows the moisture levels with a lag of one to a few years. A wavelength shape in the cross correlation functions and power spectrum indicate coherence between the precipitation and budworm records at 45 years for Oregon and 28 for New Mexico, and significant negative lags at the half period lengths of 22 and 14 years, respectively.

Work with the Ludwig-Jones-Holling model and the Bud-Lite model also indicate an association between budworm and climate, indicating first that increased precipitation results in more food resource for the budworm, and ultimately more budworms, and that that good matches between foliage and budworm phenology is key to outbreak initiation.

Collectively, these analyses indicate that both budworm populations and precipitation have inherent oscillating characteristics, and that input of the external climatic pulse has a tendency to entrain the budworm system to oscillate at a similar frequency, and to synchronize disparate centers of budworm populations across large regions. This is, in essence, a modification of what is called the "Moran effect". Moran theorized that two populations with similar internal dynamics could be brought into synchrony over large areas by the influence of correlated external factors such as climate.

WORKSHOP

Interactions Among Bark Beetles, Pathogens, and Conifers in North American Forests: Regional Research Project W-187

Moderator: Fred Baker

Regional Research project W-187 is a group of University and Forest Service scientists focusing on Interactions between bark beetles and fungi in North American conifers. Investigators are working on one or more of the following objectives:

- Characterize the roles and mechanisms by which biotic and abiotic factors predispose trees to bark beetle attack and subsequent mortality.
- Characterize interactions among conifer hosts, bark beetles, their natural enemies, vectored fungi and pathogens for the purpose of developing effective management practices.
- Characterize the taxonomic diversity and genetic structure of key fungal pathogens and symbiotic fungi associated with insects on North American conifers.

We met briefly at the meeting to bring people up to date about our renewal and future efforts. The project was approved for the period 1999 - 2004. We meet annually for 1-3 days to discuss progress and to coordinate future research. While many of the investigators are affiliated with agricultural experiment stations, there are procedures to allow membership for projects not associated with the AES, so anyone can become a member.

For more information on W-187, visit the website at:
http://www.usu.edu/~forestry/w187/w187.htm or contact past-chair Fred Baker (forpest@cc.usu.edu) or 435-797-2550

WORKSHOP

Biological Control of Bark Beetles

Moderators: Ken Raffa and Diana Six

Welcome & Opening Remarks: Ken Raffa

Ken Raffa: Using Semiochemistry disparities to improve predator monitoring & conservation
Wayne Berisford: Parasitism by both *Roptrocerus* and *Dendrosoter* in Australia
Fred Stephen: Using nutrient sources to enhance parasitoid survival and oviposition
Brian Sullivan : Host location by the parasitoid *Roptrocerus xylophagorum.*
Eva Pettersson: Odor perception and preferences in bark beetle parasitoids
Diana Six: Parasite attraction to microbial volatiles: *Ips pini*
General Discussion: Diana Six, moderator

Using Semiochemical Disparities Among Bark Beetles and Predators to Improve the Monitoring & Conservation of Natural Enemies

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It has long been known that predators of bark beetles use beetle pheromones to locate their prey (Wood 1982). However, these predators do not necessarily prefer the same enantiomers, secondary components, and host volatiles as do the bark beetle species which they attack (Payne et al. 1984, Raffa & Klepzig 1989, Herms et al. 1991, Raffa & Dahlsten 1991). Moreover, even though predators can be important regulators of bark beetle populations (Raffa 1995, Reeve 1997, Turchin et al. 1991, 1999), there can be significant differences in their peak activity periods (Raffa 1991, Aukema et al. submitted, a,b). These behavioral, ecological, and phenological disparities among predators and prey may provide partial and presumably temporary escape to bark beetles from their natural enemies, and represent a coevolving system. These differences may also be used by forest managers to improve control of bark beetle pests.

We are considering three ways to improve biological control of the pine engraver, *Ips pini* through an increased understanding of pheromonal interactions among these beetles and their major predators: monitoring, conservation, and augmentation. Work on augmentation is still underway, so we report concentrates on the first two tactics.

Pheromones are routinely used to monitor both bark beetles and their predators, and the relative abundance of each can provide a useful measure to pest managers. However, in those systems in which bark beetles and predators show varying preferences for different pheromone components, these estimates can be heavily biased by which lure is selected. We conducted a field behavioral choice experiment in which we evaluated which of 6 combinations of (+) vs. (-) ipsdienol with or without lanierone emulated responses by pine engravers and natural enemies to infested logs. Based on the choice of lure and the timing of deployment, the ratio of *Ips pini* to predators deviated by as little as 12% from infested logs, to as much as 1200% (Aukema et al. submitted a). Thus, there appears to be high potential to use this information to improve monitoring approaches.

Although pheromones can be used to trap out large numbers of bark beetles, they can also cause high mortality to predators that respond to these same lures (DeMars et al. 1980). We evaluated whether use of various pheromone blends, and at different times of the flight season, could reduce this problem during simulated trap out. Depending on these factors, the ratio of *Ips pini* to predators captured ranged from as low as under 1.0 (more predators than bark beetles removed), to as high as 39X (Aukema et al. submitted, b). These results show that behavioral disparities among bark beetles and predators are maintained even under no choice conditions, and that the appropriate selection of chemicals and deployment times can greatly reduce predator losses during trap out programs.

We are continuing these investigations, and expanding them to quantify contributions of host tree and microbial volatiles to search behaviors by bark beetle predators and parasites.

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Potential Interactions Between Introduced Bark Beetle Parasitoids In Australia

C. Wayne Berisford, Dept. of Entomology, University of Georgia and Donald L. Dahlsten, Center For Biological Control, University of California, Berkeley

The parasitoids, *Roptrocerus xylophagorum* Ratzeburg (Hymenoptera: Torymidae) and *Dendrosoter sulcatus* Muesebeck (Hymenoptera: Braconidae) were introduced into Australia in the early 1980's to help control the bark beetle *Ips grandicollis* (Eichhoff). *Roptrocerus* became established immediately and spread rapidly throughout the range of *I. grandicollis*. *Dendrosoter*, on the other hand, did not establish over wide areas and has been only recently been confirmed to be common. Due to the differential in establishment times, considerable data are available on parasitism by *Roptrocerus* in the absence of other parasitoids. We now have an opportunity to evaluate interactions between the two parasitoids to determine if *Dendrosoter* contributes additional bark beetle mortality or simply usurps hosts from *Roptrocerus*. Since the parasitoids have substantial differences in oviposition behavior, I. e. through the bark vs from *Ips* egg galleries, we hypothesize that there will be additional parasitism. Data are being gathered to make the determination during the 2000 field season.

Using nutrient sources to enhance parasitoid survival and oviposition.

F. M. Stephen and L. E. Browne, Dept. of Entomology, University of Arkansas

Parasitoids of *Dendroctonus* bark beetles are seldom considered important in the population dynamics of their hosts. In the case of the western bark beetles, *D. brevicomis* and *D. ponderosae*, typically there are less than two generations per year, individual infested trees are often spread throughout stands and parasitoids must be effective in finding hosts only at very specific times of the year. These characteristics are somewhat in contrast to *D. frontalis* that has up to nine generations per year, highly aggregated infestations, and host bark beetles being

continually available to parasitoids. We thus consider *D. frontalis* as a species well suited for testing an artificial food to enhance parasitoid longevity and fecundity.
We also recognize the difficulty of demonstrating the importance of parasitoids in bark beetle population dynamics because sampling to effectively measure parasitoid impact is exceptionally difficult and seldom done.

During the past several years we have been working with about 6 species of parasitoids in the southern US, all of whom are synovigenic, and thus require food to produce additional eggs beyond the limited number they contain as newly eclosed adults. We have developed an artificial diet, Eliminade^{TM}, that increases parasitoid longevity, increases production of immature eggs and presumably parasitoid fecundity, and decreases egg resorption when hosts are not available.

With an effective food available, we have focused on development of an applied biological control tactic through conservation/manipulation of parasitoid populations in *D. frontalis* infestations. This has resulting in research on application technologies beginning with Eliminade^{TM} sprays on to tree boles from backpack sprayers, and later to encapsulation of Eliminade^{TM} in food balls and their application to tree boles via compressed air paint-ball guns. Recent discovery of the remarkable distribution of *D. frontalis* parasitoids in pine canopies and our ability to effectively feed parasitoids in that region offer important new opportunities for Eliminade^{TM} delivery by aerial methods.

Host location by the parasitoid *Roptrocerus xylophagorum*

Brian Sullivan, Katja Seltmann, Eva Pettersson and Wayne Berisford
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We have been examining the processes of host location in the parasitoids of bark beetle larvae using the Pteromalid ectoparasitoid *Roptrocerus xylophagorum* and one of its hosts, the pine engraver beetle *Ips grandicollis,* as a model system. These insects were reared continuously on bolts of loblolly pine in the laboratory, and the anemotaxis of *R. xylophagorum* in response to host-associated odors was examined in a Y-tube olfactometer. Odors of steam-distilled pine resin or artificially damaged pine bark failed to attract *R. xylophagorum*, and live host insects (*I. grandicollis* larvae and pupae) removed from infested pine bolts were likewise unattractive. However, feeding by *I grandicollis* larvae on "sandwiches" of freshly-excised pine bark for three days stimulated strong attraction in the parasitoids, indicating that host-location cues arise from an interaction between the host and the tissues of its food plant. Feeding by adult female *I grandicollis* in bark sandwiches likewise stimulated strong attraction in *R. xylophagorum,* suggesting that the cues arising from the host-plant interaction may not be specific to the parasitism-susceptible life stages of the host. Odors of fresh pine bark substantially reduced *R. xylophagorum*'s attraction to odors of host-infested bark when these two odors were presented in the same olfactometer arm, indicating the presence of attractant antagonists for these parasitoids in uninfested bark tissue. These antagonists may allow *R. xylophagorum* to avoid bark with relatively few hosts and thus might play a role in maximizing this parasitoid's foraging efficiency.

Some evidence suggests a role for bark beetle-associated microbes in producing host-location cues for *R. xylophagorum*. In initial trials, bark from pine bolts inoculated with a rinsate of adult *I. grandicollis* and incubated two weeks were significantly attractive to *R. xylophagorum*, however, our efforts to repeat this experiment have so far yielded inconsistent results. In our Y-tube olfactometer, *R. xylophagorum* were attracted to a synthetic blend of 7 oxygenated monoterpenes present in attractive distillates of host-infested bark, and studies of the odors associated with the growth of bluestain fungi in pine bark showed that two bluestain species associated with hosts of *R. xylophagorum* could stimulate significantly increased concentrations of all seven of these compounds. In choice experiments in which *R. xylophagorum* were presented simultaneously with bark infested with *I. grandicollis* larvae that were either axenic or possessing their normal microbial complement, the parasitoids showed a significant preference for the bark infested with non-axenic hosts.

Interactions of bark beetle natural enemies and beetle-associated fungi

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It is not known how parasitoids of bark beetle larvae locate beetle-infested trees. Parasitoids of adult bark beetles locate their hosts using beetle aggregation pheromones. However, parasitoids attacking larval stages are not likely to be attracted to pheromones, as appropriate host beetle larval stages are not present until many days or weeks after pheromone production has ceased. Other cues associated with brood development, therefore, are likely to be used.

Cues utilized by parasitoids in host habitat location are often volatile chemicals. In order for host habitat-associated volatiles to be useful to a parasitoid for host and/or host habitat location they must be consistently associated with the host, and be temporally specific and informative. Volatiles produced by beetle-associated fungi are one possible source of such cues.

Bark beetles are believed to be universally associated with fungi. Further, particular beetle species are associated with one or two specific filamentous fungi as well as yeasts. These fungi are disseminated from tree to tree by the beetles on the exoskeleton or in specialized structures called mycangia. As well as being consistently associated with host beetles, the fungi may also provide temporally specific and informative cues. Fungi produce a wide range of volatile compounds. Beetle-associated fungi produce volatiles that vary by taxon of the fungus. For example, yeasts produce primarily oxygenated monoterpenes while *Ophiostoma* species uniquely produce sesquiterpenes. Volatile profiles of fungi also change considerably over time and with particular growth stages of the fungus thus allowing for temporal changes in volatile cues corresponding with various stages of insect hosts.

We have begun to test the hypothesis that fungal cues are involved in host habitat location by bark beetle larval parasitoids using the pine engraver, *Ips pini*, its associated fungi, and a common larval parasitoid. Our first step was to identify what fungi are the most consistent associates of this beetle. We did this for two populations: one in California, and one in Montana.

The California population of *I. pini* had a greater diversity of fungal associates; however, for both populations, yeasts were the most consistent associates, followed by *Ophiostoma ips*, a blue stain fungus (Tables 1 & 2).

Next, we reared parasitoids from *I. pini*-infested slash for use in attraction trials. Despite extensive rearing efforts, very few parasitoids were recovered. Of 23 parasitoids collected from rearing containers, the most common (21) were a *Roptrocerus* sp. For the trials, we used a static-air glass Y-tube olfactometer to test for attraction of the parasitoids to the most common yeast and to *O. ips*. The olfactometer had a "finish line" drawn 1cm from the end of each arm. Into one arm of the olfactometer was placed a small plug of pine twig agar with yeast or *O. ips*, a second arm received pine twig agar only, and the third arm received a female *Roptrocerus*. Each female was observed for 20 minutes. During this time, if she passed a finish line, she was considered to have made a "choice." If she remained in an arm for longer than 5 minutes, she was considered to be "arrested".

Numbers of parasitoids used in the trials were too low to statistically test for significant differences of choices or arrestments for the two fungi. In trials testing for attraction to *O. ips*, there appeared to be no apparent choice of the fungus over the control (agar alone). Out of 14 trials, 5 females made no choice (remained in release arm), 4 chose the control, and 5 chose *O. ips*. Arrestment showed a similar pattern with 5 arrested in release arm, 5 in the O. *ips* arm, and 3 in the control arm. One female was not arrested and continued to wander. In trials using the yeast, a trend was observed. 7 females made choices for, and were arrested in, the yeast arm, while only one chose, and was arrested in, the control arm.

Further work with *I. pini* and the mountain pine beetle, *Dendroctonus ponderosae*, and their fungal associates and parasitoids is planned.

Table 1. Fungi associated with Ips pini in Lassen National Forest

	Stage isolated from:			
Fungal spp.	**Larvae** n=61	**Larv. Gallery** n=51	**Pupal Cham.** n=22	**Adult** n=37
*Yeasts	60 (98.4%)	51(100%)	21 (95.5%)	32 (86.5%)
**Ophiostoma ips*	25 (41.0%)	34 (66.6%)	15 (68.2%)	20 (54.1%)
**O. bicolor*	0	10 (19.6%)	0	9 (24.3%)
O. piceaperdum	0	1 (2%)	0	0
O. stenoceras	0	0	0	1 (2.7%)
Ceratocystis olivaceapini	0	6 (11.8%)	0	0
Ceratocystiopsis minuta-bicolor	0	4 (7.8)	0	2 (5.4%)
**Leptographium sp. A*	2 (3.3%)	5 (9.8%)	0	
Leptographium sp. C	8 (13.1%)	6 (11.8%)	0	
Leptographium sp. D	1 (1.6%)	2 (3.9%)	0	
Leptographium sp. E	1 (1.6%)	2 (3.9%)	0	
**Graphium sp.*	1 (1.6%)	1 (2.0%)	4 (18.2%)	7 (18.9%)
**Trichoderma sp.*	0	0	0	10 (27%)
*Unidentified demateacious sp.	2 (3.3%)	6 (11.8%)	0	2 (5.4%)
*Unidentified hyaline sp.	1 (1.6%)	5 (9.8%)	4 (18.2)	2 (5.4%)
Unidentified floccose sp.	0	0	2 (9.1)	0

* species present in CA and MT

Table 2. Fungi Associated with Ips pini in Lolo National Forest

	Stage isolated from:			
Fungal spp.	**Larvae** N=40	**Larv. Gallery** N=40	**Pupal Cham.** n=40	**Adult** N=40
*Yeasts	40 (100%)	39 (97.5%)	40 (100%)	40 (100%)
**Ophiostoma ips*	34 (85%)	20 (50%)	32 (80%)	38 (95%)
**O. bicolor*	17 (42.5%)	6 (15%)		0
**Leptographium sp. A*	10 (25%)	3 (7.5%)	0	0
Leptographium sp. B	2 (5%)	0	0	0
**Graphium sp.*	0	0	0	0
Chalara sp.	0	0	1 (2.5%)	0
**Trichoderma sp.*	0	4 (10%)	0	27 (67.5%)
**Unidentified demateacious sp.*	0	8 (20%)	25 (62.5%)	0
*Unidentified hyaline sp.	0	2 (5%)	0	0
Unidentified floccose sp.	0	0	2 (5%)	0
Unidentified yellow sp.	0	0	1 (2.5%)	0
Unidentified catenulate sp.	0	0	1 (2.5%)	0

* species present in CA and MT

WORKSHOP

Current Issues in Defoliator Management

Moderator: John Wenz,

Participants: About 30 people participated in discussions focused around presentations concerning *Nepytia janetae*, a geometrid defoliator in Arizona and *Orgyia pseudotsugata*, the Douglas-fir tussock moth. Presentations were made by Bobbe Fitzgibbon, Gary Daterman, John Wenz and Dave Bridgwater.

Nepytia janetae:

Bobbe Fitzgibbon, USDA Forest Service, Southwest Region, Forest Health Protection, Flagstaff, AZ.

Nepytia janetae is a little known geometrid (looper, inchworm) with no common name that feeds on spruce and true fir at high elevations (9,000 feet and above) in the southwestern United States. This insect was described by Fred Rindge, emeritus curator at the National Museum of Natural History in New York, from adult specimens collected in New Mexico in the 1960s. The biology of the insect is still being determined. Adults begin to emerge in June and females lay clusters of small vase shaped eggs on the dorsal surface of the needles of host trees. Larvae are present from at least September until late May to early June. The larval stage appears to feed on warm days throughout the fall, winter, and spring despite the cold temperatures found at high elevations. In June, larval, pupal and adult stages have been observed.

No record of episodes of defoliation by *N. janetae* had been recorded prior to the outbreak discovered in the Pinalino Mountains of Arizona. The 1997 annual aerial detection survey map of Mt. Graham showed 447 acres of damage attributed at that time to an unknown geometrid. Elaine Lowery, a wildlife biologist with the Mt. Graham Red Squirrel Project, collected and reared caterpillars, found feeding in December, to adulthood for identification. Concern for the habitat of the endangered Mt. Graham Red Squirrel prompted the establishment of a series of impact plots on the mountain. Some bark beetle activity was noted on Mt. Graham during a ground check in the spring of 1998. Looper defoliation continued throughout the winter of 1998-9. Populations of spruce beetle, *Dendroctonus rufipennis,* and western balsam bark beetle *Dryocoetes confusus* began to increase and reached outbreak levels during the summer of 1999. The basal area and the number of live trees per acre of both spruce and fir have declined since the impact plots were installed in June of 1999. Little evidence of looper activity has been seen on Mt. Graham during the fall of 1999; however, bark beetle activity and associated tree mortality are expected to continue.

An additional 1,188 acres of defoliation were recorded in the White Mountains of Arizona during the summer of 1998. Most of the affected area was either in wilderness or general forest. Insect feeding here continued throughout the winter of 1998-9 and the area covered by defoliation increased to approximately 10,000 acres including a portion of the Sunrise Ski

Complex on the White Mountain Apache Reservation. Impact plots have been established in this location as well. Impacts to the recreational complex prompted a proposal to spray 6,505 acres of spruce and fir with *Bacillus thuringiensis* to protect visual quality and prevent stress to trees caused by heavy defoliation. Due to a decrease in the looper populations in the fall of 1999, the spray project has been postponed and will likely be cancelled if *N. janetae* populations remain low.

Monitoring Douglas-fir Tussock Moth with Pheromone-baited Traps: 1979-1999:

Gary Daterman, USDA Forest Service, Pacific Northwest Research Station, Corvallis, OR; John Wenz, USDA Forest Service, Pacific Southwest Region, Forest Health Protection, Sonora, CA; and Katharine Sheehan, USDA Forest Service, Pacific Northwest Region, Natural Resources, Forest Insects and Diseases, Portland, OR.

The Douglas-fir tussock moth (DFTM) causes severe defoliation of Douglas-fir and true firs in western North America. Populations of this insect are cyclic, ranging from undetectable levels to outbreak densities capable of causing tree mortality and growth loss over extensive forested areas. Because populations can transition quickly into the outbreak phase, an early-warning system has been needed to detect the early stages of such a change. With the 1975 identification and synthesis of the insect's primary pheromone component, Z-6-heneicosen-ll-one, a potent tool was made available for detecting DFTM populations. Traps baited with the synthetic pheromone proved highly sensitive and captured moths throughout the host range, including areas with no history of DFTM outbreaks and where the insect could not easily be detected by other means.

The DFTM Early Warning System was designed to monitor DFTM populations based on the number of male moths captured at key points on susceptible landscapes. Because of the potency of the pheromone, the controlled-release lures for the monitoring traps were calibrated at very low-strength so that few, if any, moths would be attracted and captured where populations were low. Increasing numbers of moths could therefore be expected to correlate with increasing populations. Accordingly, land managers could focus attention on high priority stands in areas with increasing populations, while disregarding the vast majority of the host range exhibiting relatively stable population levels.

Early Warning System plots were initially established in Oregon, Idaho, and California in 1979, and in Washington in 1980. Approximately 750 plots are currently monitored westwide, with most plots maintained annually. Five traps were placed about 30 meters apart at each plot location. Traps are put out just prior to moth flight and collected near or at the end of the seasonal flight period. Initial results indicated that average catches of 25 or more moths per trap for a plot might precede an outbreak. With experience, the threshold number of captured moths assumed to indicate a potential outbreak was increased to an average of 40 moths or more per trap.

During the first 20 years of operation, eight DFTM outbreaks have occurred where trap plots were either in the near proximity (<5 miles) of where defoliation took place, or in the sub-region, but distantly located (>50-miles). The resulting outbreaks ranged in size from negligible to

420,000 acres. Two of the eight outbreaks are now in progress: one in northeastern Oregon, where elevated trap catches in 1997 and 1998 preceded defoliation over approximately 20,000 acres in 1999; and another in northeastern California where increased trap catches were noted in 1998 and approximately 2,000 acres were defoliated in 1999. In all eight cases, increasing moth captures occurred either locally or within the subregion and were either used, or could have been used, as an early-warning of impending outbreaks.

The Early Warning System was never intended to predict boundaries or otherwise characterize an outbreak population; rather, it was designed to detect early indications of a potential outbreak over a general area. Once the traps provide the early-warning, additional work becomes necessary to sample other life stages over an extensive area in the general vicinity of the trap plots to characterize local DFTM populations. When only a few trapping sites are situated in a large area, the problem of follow-up sampling can be costly and time-consuming because so much area should be sampled. In such cases, some resource managers have elected to install additional plots in the year following elevated trap catches. Such supplemental trapping may prove helpful if its application is timely relative to the development of the outbreak. However, the effectiveness of supplemental trapping could be minimal or the data even misleading if applied late in the outbreak cycle. Trap capture numbers have been observed to decline during peak outbreak years in areas with high DFTM populations. These lowered trap captures presumably occur because the low-strength of the synthetic monitoring lures is less attractive to male moths than the high levels of natural female moth pheromone produced by the large number of females in the outbreak area. Not only do the synthetic lures emit a much lower amount of the primary pheromone, they are also lacking a secondary pheromone component which was reported in 1997, and which greatly enhances the attraction. Such anomalous results could lead to misinterpretations concerning performance of the trapping system, and possibly for decision-making with regard to management of the outbreak.

Our initial analyses of the 20-year trapping results suggest the following: 1) Increases in trap captures do provide a one to two year early warning of aerially detectable DFTM defoliation, even when plots are located some distance from the area of eventual defoliation; 2) Following the early-warning, extensive follow-up sampling of other life stages should be conducted to delineate and characterize the populations; 3) There is a need for more consistent guidelines and procedures in conducting the follow-up sampling to predict subsequent DFTM activity; 4) Although the early-warning system does the intended job, there may be opportunities for adaptive modifications to the current system, including changes in the number and placement of traps and plots and the use of supplemental traps.

Current Status of the 1997-1999 Douglas-fir Tussock Moth Outbreak in the Sequoia and Kings Canyon National Parks and the Sequoia National Forest, Southern Sierra Nevada, California:

John Wenz, USDA Forest Service, Forest Health Protection, Sonora, CA.

The 1997-1999 Douglas-fir tussock moth (DFTM) outbreak in the southern Sierra Nevada, is the sixth tussock moth outbreak to occur in California since the 1935-1937 outbreak in Mono

County. Feeding injury on white fir was first detected in August, 1997 on the Hume Lake District, Sequoia National Forest and in the Sequoia and Kings Canyon National Parks. This discovery was preceded by 2 to 3 years of increasing pheromone trap catches in the central and southern Sierra Nevada (no pheromone plots were established within the outbreak area). Subsequent pupal/ egg mass and larval sampling indicated a general area of infestation to cover approximately 44,000 acres including true fir stands on the Tule River/ Hot Springs and Greenhorn Districts on the Sequoia National Forest.

Moderate to heavy defoliation occurred in 1998 over about 6,000 acres (13.6% of the general infested area) primarily in high-use areas in the vicinity of Grant Grove and along the heavily used scenic General's Highway in Sequoia and Kings Canyon National Parks and in nearby areas on the Hume Lake District. Small areas in private ownership were also affected. Larval feeding in 1998 resulted in localized tree mortality and top-kill, resulting in the creation of hazard trees and unplanned small openings in and around developed sites. In addition, visitors, National Park and Forest Service employees, concessionaires and other forest workers, reported numerous incidences of mild to severe tussockosis (an allergic reaction to tussock moth hairs) in the summer of 1998.

The Sequoia/ Kings Canyon National Parks conducted an Environmental Assessment in 1998-1999 to evaluate DFTM management alternatives for the summer of 1999. In the spring of 1999, analyses of 1998-1999 egg masses indicated that levels of the DFTM nuclear polyhedrosis virus were increasing in the population (personal communication, Imre Otvos, Canadian Forest Service, Pacific Forestry Centre, Victoria, British Columbia) suggesting that tussock moth populations would likely collapse in 1999 due to natural factors, and the decision was made not to implement any direct control. Subsequent observations in the summer of 1999 found that populations did decline without causing significant additional resource damage.

In summary: (1) The most recent DFTM outbreak in the southern Sierra Nevada of California followed the historical 3 to 4 year pattern of many tussock moth outbreaks. The release year (1997) was characterized by light to moderate defoliation generally restricted to the current years growth and upper 1/3 to 1/2 of the tree crown. The following year (1998) was the peak year in which most of the damage, including reports of tussockosis, occurred. Populations collapsed in 1999 (decline phase) due to natural factors without causing significant additional damage; (2) The outbreak was predicted by the early-warning pheromone system despite pheromone plots not being established in the outbreak areas. The importance of conducting adequate follow-up sampling in priority areas was demonstrated. (3) The majority of the damage occurred during the second year peak phase of the outbreak. If resource managers consider DFTM damage to be unacceptable, timely NEPA analysis and decision-making should occur to allow any decisions involving prevention and/or suppression to be implemented effectively to minimize feeding by second year peak phase populations.

Current Status of the Douglas-fir Tussock Moth in Oregon and Washington:

Dave Bridgwater, USDA Forest Service, Pacific Northwest Region, Natural Resources, Forest Insects and Diseases, Portland, OR.

Douglas-fir tussock moth (DFTM) early-warning pheromone trapping results in the Pacific Northwest from the past few years have shown a dramatic increase in tussock moth populations over a wide geographic area. In 1999, DFTM defoliation was reported over about 20,000 acres in northeastern Oregon. Larval and pupal sampling indicates that these areas will be further defoliated in 2000, suggesting that there is a high probability of a continuing tussock moth outbreak in 2000 or 2001. In preparation for such an occurrence, the Pacific Northwest Region decided to prepare an Environmental Impact Statement (EIS) to analyze various options to deal with the defoliation and possible tree mortality such an outbreak could cause.

An interdisciplinary team was formed in June of 1999. Their task is to prepare an EIS by May 30th, 2000. The team asked the forests to identify priority areas where tussock moth defoliation would cause unacceptable damage to critical resources. The forests identified about 900,000 acres of high priority areas. These areas were primarily critical wildlife habitat areas and recreation areas where tussockosis caused by the larval hairs would pose a threat to human health.

The EIS is looking at 3 alternatives, no action, treatment of just the high priority areas, and treatment of both high priority areas and other forest lands at risk. Only Forest Service managed lands are being considered in the EIS. Treatment options are the use of the tussock moth's neuclopolyhedrosis virus (TM Biocontrol) and Bacillus thuringienensis kurstaki, or a combination of these two materials.

WORKSHOP

Effects of Fire on Forest Arthropods and Pathogens

Moderator: Christine G. Niwa,

Effects of Prescribed Fire on Dwarf Mistletoe Infestation in Southwestern Ponderosa Pine

Dave Conklin, USDA Forest Service, Southwestern Region, Albuquerque, NM

Effects of several recent prescribed fires (underburns) on dwarf mistletoe infestation are being monitored on the Santa Fe National Forest in northern New Mexico. Results here are from two fires conducted in October 1995 and March 1996 in pole-size stands of ponderosa pine with moderate to heavy levels of infection. Both stands had been "sanitation thinned" to 10-12 foot spacing about 12 years earlier. Three rectangular plots were installed in the October burn area in June 1994, while a single previously installed (1991) plot was remeasured just prior to the March fire. DMR's were re-taken three years after the fires, at which time fire-induced tree and branch mortality had subsided. Ratings were again done in June 1999 (about 8 months later) on the three October fire plots, allowing 5-year comparisons with similar unburned plots (PTIPS). Most trees less than 4" dbh were killed by the fires; results shown are for the larger trees only (n=415 for October fire; n=130 for March fire).

The October fire resulted in average crown scorch of 28%, 63%, and 57%, with mortality of 9%, 36%, and 19% of trees, respectively, after three years. The March fire produced an average scorch of 71% with 3-year mortality of 26%. Bark beetle activity elevated mortality moderately in the October burn, but only minimally in the March burn. Both fires showed trends of increasing scorch with increasing tree DMR. Mistletoe infection reduced tree survival in both burned areas, but only for the most heavily infected trees--DMR 5 and 6--with severe scorch--90-100%. On these plots, 29% of the DMR 5 and 70% of the DMR 6 trees were dead after three years, while about 10% of the other trees died.

A smaller proportion of surviving infected trees had increases in their DMR after 5 years on burned than on unburned plots (18% vs. 37%), while a much greater proportion had decreases (29% vs. 5%). Most, if not all, of these differences was a result of fire-induced mortality of infected branches (scorch pruning). Long-term effects of scorch pruning will undoubtedly vary from tree to tree. Death of infected branches will tend to improve growth and longevity, and reduce spread of the parasite to adjacent trees. However, ratings are expected to rebound on many trees, as the parasite continues its upward spread in the raised crowns. About 10% of previously infected surviving trees had no visible infection when last checked 3 to 3.7 years after the fires. It is also likely that some recently infected trees not yet showing visible infection were "sanitized" by partial crown scorch.

Combined effects of tree mortality and scorch pruning reduced plot DMR's as follows: Plot 1 (28% scorch): projected 2.72, measured 2.37; Plot 2 (63% scorch): projected 4.55, measured 3.49; Plot 3 (57% scorch): projected 2.46, measured 1.85; Plot 4 (71% scorch): projected 3.75, measured 2.28. Measured values are 5 years after plot establishment (about 3.7 years after fire) for Plots 1-3, and 3 years after fire for Plot 4. Projected values are based on intensification observed on similar unburned plots (and on the plot itself in the case of Plot 4). These plots, along with several others established in more recent (1997-99) burns, will be periodically rechecked to better quantify these effects.

Bark Beetle Outbreaks Following the Little Wolf Fire

Ken Gibson, USDA Forest Service, Northern Region, Missoula, MT

The Little Wolf Fire, in northwest Montana, began on the Kootenai NF on August 12, 1994 and spread to the Flathead NF the next day. By August 26, it had burned with varying intensities on more than 15,400 acres--10,600 of them on Tally Lake RD. Most of the area was comprised of mixed conifer stands--40% spruce/fir (1/3 Engelmann spruce, 2/3 subalpine fir), 47% lodgepole pine (many affected by mountain pine beetle outbreaks in the 1980s), 10% Douglas-fir, and 3% western larch.

Assessments of fire intensity showed that fire effects ranged from total stand replacement to little apparent damage. The area was assessed for bark beetle potential in early October. No evidence of bark beetles was found in 1994. Stand conditions in many areas suggested susceptibility to bark beetles in 1995 would be high--dependent upon amount of tree damage. Few in the most severe category would attract beetles. Lesser affected portions seemed particularly susceptible to some bark beetles, especially Douglas-fir and spruce beetles (*Dendroctonus pseudotsugae* Hopkins and *D. rufipennis* [Kirby]) which take advantage of host disturbances to build populations to epidemic levels. In 1995, we re-assessed bark beetle conditions and potential. We found fewer Douglas-fir, but more down and standing Engelmann spruce, infested by beetles than expected.

About 2,000 acres contained infested spruce ranging from 1-20 trees per acre. Another 5,000 acres, within a 5-mile radius, had much large-diameter, old-growth spruce--most of the District's "old-growth" component. Because of recent past logging, remaining old-growth stands were increasingly valuable and the desire to protect them from spruce beetle depredations became paramount. Also in 1996 we found evidence of increasing Douglas-fir beetle populations. Surveys showed areas where large amounts of Douglas-fir windthrow had been infested and outbreak development seemed likely.

Salvage operations, the objectives of which were to salvage fire-damaged trees before value was lost, and reduce bark beetle populations, continued in 1997. Approximately 1,200 acres were to be salvaged to remove beetle-infested spruce. Site sensitivity required helicopter yarding on 80% of the area. Because not all infested trees could be removed before beetles emerged, we installed pheromone-baited funnel traps where salvage would not be completed until late summer. In twenty areas, we installed clusters of ten traps each. Traps, containing frontalin and alpha-pinene, were hung in May and removed in late August. We collected an estimated 20,000 beetles. Combined efforts of trapping, salvage, and trap trees were successful. No new beetle-infested trees were found in 1997.

During 1997, we found high amounts of beetle-infested Douglas-fir in fire-affected and adjacent stands. While salvage continued, not all areas could be harvested prior to beetle flight in 1998. We used pheromone traps again in 1998, hanging 175 traps mostly in 9-trap clusters. Traps baited with different combinations of pheromone lures were hung April 27-30. Most lures were commercially available frontalin, ethanol and methylcyclohexanol. As a comparison, an "experimental" combination of frontalin, ethanol and seudenol was used in 36 traps. Beetles were first caught on April 28. Peak beetle flight occurred between July 7-15. Traps were removed in late August. An estimated 860,000 beetles were caught. About 125 "spill-over" trees were attacked near traps and an additional 700 were killed in the general trapping area--all of which were removed in fall 1998. Between trap catches--perhaps the equivalent of 1,000 attacked trees--and infested trees removed, beetle populations in the burn area have been reduced to nearly endemic levels.

Spruce beetle populations have returned to endemic levels throughout the District. No spruce beetle-killed trees have been observed during subsequent annual aerial surveys. Only a few have been found during extensive ground surveys--none close to treated areas. Douglas-fir beetle populations, however, are still at epidemic levels on parts of the District and in much of northern Idaho and western Montana. We currently are experiencing the most extensive outbreak in recent history. While declining, beetle populations remain high.

The Little Wolf Fire presented difficult challenges to forest managers. But it also provided an opportunity for operational use of pheromone-based management strategies which had been previously used only on much a smaller scale. Silvicultural manipulations used to prevent bark beetle outbreaks will always be preferred to tactics used to suppress them. But occasionally, bark beetle populations will build more rapidly than our ability to respond. In such instances, the availability of strategies to hasten the return of outbreak populations to endemic proportions and reduce beetle-caused mortality to more acceptable levels can be of great value.

Effects of prescribed fire on oribatid mite assemblages at Blacks Mountain Experimental Forest: Preliminary results from a fall burn

Nancy Gillette Rappaport, USDA Forest Service, PSW Research Station, P.O. Box 245, Berkeley, CA 94701; Karen Lamoncha, Humboldt State University, Arcata, California 95521; Michael Camann, Humboldt State University, Arcata, CA 95521.

Prescribed burns were conducted in the fall of 1997 at Blacks Mt. Experimental Forest in Lassen County, California, the site of a long term, large scale ecosystem study designed to test the ecosystem effects of enhancing late-seral characteristics of stands of east-side Sierra Nevada ponderosa pine. Harvesting took place during 1996 to create 100-hectare plots of two levels of stand structural diversity: 1) high diversity plots characterized by multiple canopy layers, the presence of many large, old-growth trees, dense clumps of small trees, many small canopy gaps and forest floor openings, and abundant snags; 2) low diversity stands, characterized by a single canopy layer with well spaced trees, few large canopy gaps and forest floor openings, few snags per acre and a minimum of large old growth trees. Each of the harvested plots was treated with prescribed fire one year post-harvest in a split-plot design. Post-burn data based on heat sensor readings and duff-pin measurements suggest that the level of consumption in the plots was "low" for the high diversity plot and "moderate" for the low diversity plot.

Microarthropod sampling consisted of 5 east-west oriented 6-meter transects/plot centered on randomly selected ponderosa pine trees. Sample points along each transect consisted of points at zero, one, two and three meters east and west of the tree base. Sampling methods consisted of sifted soil/litter removed from a 12-inch diameter circle at each sampling point, with the siftate transported to the laboratory for Berlese extraction of microarthropods. All Acari were sorted to suborder, and Oribatei identified to genus, species, or morphospecies, depending on availability of suitable keys. The results presented below consist of only one replicate per stand structural diversity treatment; valid hypothesis testing will be possible only when samples from the second replicate (two more plots) are identified and analyzed. Approximately 20,000 individual mites were recoverded and identified for these two plots.

Results from high diversity stand: Thirty-four oribatid taxa were identified in the unburned portion of this unit, and 40 from the burned portion. There were slight reductions in mean numbers of oribatids sample in the burned split-plot. Although species richness was not different in the burned and unburned split-plots, community structure was different (as measured multiple response permutation procedures). Species diversity (Shannon index) was slightly higher in the burned portion.

Results from low-diversity stand: Forty-six oribatid taxa were identified in the unburned split-plot, and 22 in the burned split-plot. Mean numbers of individual oribatids were much lower in the burned split-plot, as were species richness and species diversity. Community structure was also different in the burned and unburned split-plots.

In summary, prescribed fire resulted in changes in community structure in both the high and low diversity plots. However, numbers of individuals and species richness, evenness, and diversity were reduced by fire only in the low diversity plots, which was subjected to a more intense fire than was the high diversity plots. This outcome suggests either an interaction between fire and stand structural diversity, or differences in the prescribed fire treatment in the high and low diversity plots. Measurements provided by fire research team suggest that there were real differences in fire intensity in the two plots, but those results have not yet been fully analyzed. As with any fire, both were patchily distributed and measurement of fire intensity was not closely linked to the arthropod sampling points. Until more of the replicated plots have been analyzed and retrospective assessments of fire intensity are complete, it is not possible to tease apart the potential interaction between the two treatments, fire and stand structural diversity. Our sampling protocol has been revised to incorporate fire intensity measurements at each individual arthropod sampling point, and we strongly encourage that this practice be considered standard for all such work.

Effects of Fall and Spring Underburning on Litter Dwelling Macroinvertebrates in a Ponderosa Pine Ecosystem

Christine G. Niwa, USDA Forest Service, PNW Research Station, Corvallis, OR

Prescribed burning is increasing being used as a tool to reduce fuel loadings, thin out dense regeneration, and reduce the threat of catastrophic wildfire. Historically, wildfires occur in the late summer and fall, when fuels are dry and lightening strikes frequent. However, the majority of prescribed fires in ponderosa pine type are now being conducted in the spring, a time when trees are physiologically active and the phenology of many arthropods may cause them to be more exposed to burning. A replicated study on the Malheur National Forest near Burns, OR was designed to look at the influence of fall, spring, and unburned treatments on arthropod communities.

The objectives of this study were: 1) to describe the ground beetle (Carabidae) and spider communities for the Burns study area; 2) to determine differences in ground beetle and spider abundance between treatments; and 3) to determine treatment effects on community structure of ground beetles and spiders. Pitfall traps were used to assess litter macroarthropods both pretreatment (1997) and posttreatment (1998).

From over 4,000 specimens, twenty-eight species of carabids were identified. The four most common species, *Pterostichus protractus, Trachypachus holmbergi, Calosoma luxatum*, and *Amara conflata*, comprised 90% of all specimens trapped. The carabid community at the Burns study site was comprised of species typical of open, mid-elevation, east side forests. Two species, *Amara sanjuanensis* and *Bembidion praticola*, were new records for Oregon. No rare, potentially threatended, endangered, or exotic carabid species were collected.

There were no statistical differences between total carabid abundance in the three treatments. Of the four most common species, *T. holmbergi* was the only one to show significant differences between treatments, being more abundant in fall burns than in controls. It has characteristics of a pioneer species, it is an omnivorous, opportunistic, scavenger that has fully developed wings and flies well. Simpson's diversity index was significantly higher in the fall burning treatment than spring or control. This is consistent with a previous study that reported increased ground beetle diversity after fire in jack pine.

Twenty-seven species, five morpho species, 29 genera, two subfamilies, and one family of spiders were identified from over 11,500 specimens. Eight species made up 75% of the specimens collected: *Pardosa dorsalis, Gnaphosa muscorum, Zelotes fratris, Z. lasalanus, Z. puritanus, Thanatus formicinus, Calilepis ermella*, and *Haplodrassus eunis*. The wolf spider (Lycosidae), *P. dorsalis*, was by far the most abundant species, making up over 40% of the specimens trapped.

The abundance of total spiders was significantly lower in both the spring and fall burn compared to the control. This relationship also holds true when *P. dorsalis* is examined alone. *P. dorsalis* breeds and reproduces in the late spring/early summer, at the same time that the spring burns were conducted, so it is likely that these fires caused substantial direct mortality to this species. Simpson's diversity index was statistically higher in fall burns than in the controls. This was due to the reduction in dominance of *P. dorsalis* after fall fires, which increased species evenness and therefore raised the index.

WORKSHOP

Disturbance in the Rockies

Moderator: Ann M. Lynch,

The moderator began with and introduction of important disturbance agents in the Rocky Mountains: fire, exotic weeds, insects, pathogens, and weather, all of which might be influenced by climate change. Interactions between these agents needs to be incorporated into the pest models, with interactions permitted at scales ranging from individual trees, seasons, and years to landscapes and centuries. We must model likely forest futures between the indigenous biotic agents and natural weather cycles in order to make good projections under scenarios including climate change and exotic weeds. This was a work discussion session without pre-arranged speakers. Approximately 12 people attended the session, including Bob Averill, Michelle Frank, Susan Heard, Elizabeth Hebertson, Susan Johnson, Ann Lynch, Mike Marsden, Dan Ryerson, Jim Speer.

Most forest types in the West are arranged along elevational gradients, with grass, desert scrub, or sagebrush at the bottom, progressing to piñon-juniper, ponderosa, mixed-conifer or Douglas-fir, spruce, spruce-fir, and maybe krummholz or tundra at the highest elevation. In some areas, lodgepole pine is an additional type above mixed-conifer. Historically, fire return intervals have been shortest in the lower elevation types, and increasing in length in the higher elevation types. The highest elevation types are cooler and usually more moist. They are protected from catastrophic fire by their weather and by the nature of the lower elevation forests. In the mid-elevation forests, particularly ponderosa and lodgepole, and less so by mixed-conifer, frequent fires keep fuel loads down, thereby insulating the types above them - crown fires don't occur often in the lower types and therefore don't progress to the higher types. This situation has been upset in historic times by fire exclusion in all types. The suppression of ground fires in the pine and mixed-conifer types has resulted in higher fuel loadings, closed-canopies of dense vegetation, and much higher risk of crown fire. Increased likelihood of catastrophic fire in the lower elevation types threatens the higher types as well. Fire exclusion, as well as other factors, has also increased the likelihood of bark beetle and defoliator outbreaks in all types, which in turn increases the risk and hazard of catastrophic wildfire. This situation of increased likelihood of pest outbreaks and catastrophic wildfire is further exacerbated by the invasion by exotic weeds and by the possibility of climate change. Further group discussion focused on the difficulties of associating beetle outbreaks to climate or weather phenomenon and on issues relevant to modeling.

The modeling discussion revolved around incorporating disturbance history information into the pest models and on issues of interaction between different agents, biotic and abiotic, and especially spruce beetle x weather x avalanche events, without coming to distinct closure on either.

How do we incorporate disturbance information gained form dendrochronologic reconstructions and other methods into the pest models? In particular, how do we address issues of scale and interaction. Mike related difficulties entailed in using partial differential equations in the model system, mostly because the distribution function used may not match either the original or simulated population. Discussion favored using the dendrochronologically reconstructed information to set limits for model behavior, rather than direct incorporation.

Ann described the pest models as operating on top of the vegetation population dynamics model, and the insect and disease models as malfunctioning more often than the vegetation models. Mike disagreed, indicating that the real problem was weak points in both systems, particularly the regeneration models in the vegetation model, and the outbreak initiation models in the insect models.

Elizabeth Hebertson described difficulties in reconstructing temporal associations between spruce beetle outbreaks, avalanches, and precipitation cycles in Utah. The avalanche cycles are atypical or at least unusual weather-related events. They produce an abundance of downed woody material which is colonized by spruce beetle. Avalanche histories can be reconstructed using scars, reaction wood visible in increment cores, and narrow rings associated with root disturbances. How can the temporal association between avalanches and weather be established or documented? Jim Speer indicated that it will be particularly difficult because the avalanche signal is binary, and although spruce beetle is a binary signal *per tree*, it isn't for the site or the region.

Bob Averill indicated that there is much that we don't know about spruce beetle, and that population dynamics often change in unforseen ways. Michelle Frank said that beetle brood is produced in scattered blowdown in the shade. Avalanches pile debris in shaded areas at the slope bottoms. Bob reported that in Alaska, and Ann reported that in the Pinaleño Mountains, some material attacked by spruce beetle was smaller than the literature indicates will be attacked. There was lots of discussion indicating that the presence of shade was very important to spruce beetle disturbance activity.

Ann reported some of Jill Wilson's Pinaleño Mountain results, which indicate that spruce beetle and western balsam bark beetle function with similar spatial dynamics but different temporal dynamics. There was discussion regarding the loss of information on past outbreaks of bark beetles in spruce and spruce-fir types because the return interval is so long - 100 to 300 years. Michelle and Bob spoke of obtaining information from lake sediments.

When looking for long term avalanche patterns, what do you see? Wound scars, somewhat like firs scars but without the repeated injury to the same zone. Increment cores show reaction wood on the tree underside, and narrow rings for some years when the roots are disturbed. This information doesn't correlate with 250-300 year climate record. The problem is with dating single spruce beetle outbreaks. Ann suggested finding survivors and looking for released growth. Apparently trees on the Wasatch Plateau don't show release patterns associated with spruce beetle outbreaks, perhaps due to *Armellaria* infections. Jim reported that some sites, such as some on the Kenai Peninsula, have trees showing spruce beetle attack scars. Elizabeth indicated that spruce beetle scars don't go below ground, and that she hopes to look at bluestain infections as an indicator of beetle activity.

WORKSHOP

NEPA, Appeals and Litigation: Implications for Insect and Disease Management

Moderators: Steve Munson and R. W. Thier

The workshop started promptly on Thursday at 10:30 with sixteen people in attendance. Everyone shared their varied experience working within the NEPA process and subsequent litigation. All agreed that involvement in project planning should begin early, especially if forest insects and diseases are part of the proposed project's purpose and need. Participants shared their thoughts on the need to communicate clearly with the project leader and methods and timing for inputs and involvement. Project involvement ranged from little, where the insect or disease specialist had little knowledge of the project until it was going to court, to complete involvement where the insect or disease specialist was part of the interdisciplinary team. Inputs to projects ranged from telephone conversations or e-mail communications to white papers, prepared in advance complete with literature citations. All inputs will become part of the administrative record and may be used in court; thus inputs must be well worded, defensible and supported by site specific data.

Some discussion was devoted to the dynamic nature of the law following interpretation by the courts and the need to stay current with recent court rulings. To insure that documents meet the current legal standard we addressed the need to have NEPA documents reviewed by an attorney before a decision is rendered. Some sources of information were shared.

Several participants shared their experiences when called as expert witnesses where projects were litigated. We discussed the need for pre-trial preparation from the attorneys; it seems some were briefed and others were not before entering the court room. When testifying, everyone agreed that the testimony needs to be consistent and based on site specific data.

Some specific points follow:

- All communications need to be consistent and carefully worded. These will become part of the administrative record and may later be used in court proceedings.
- Attorneys will make every attempt to discredit expert testimony.
- Site specific data must support expert opinion and/or scientific literature and be part of the environmental document or administrative record.
- Websites to find recent NEPA decisions:
  http://fsweb.r1.fs.fed.us/em/nepa/All_Page.html
  www.whitehouse.gov/CEQ/
  http://ceq.eh.doe.gov/nepa/nepanet.htm

The workshop concluded promptly at noon following lively discussion.

WORKSHOP

Successional Functions of Pathogens and Insects; Ecoregion Sections M332a and M333d in Northern Idaho and Western Montana.

Susan K. Hagle, Jane E. Tayor, Carol Randall Bell and John R. Schwandt

Introduction.

Most of the outcones of activities of pathogens and insects are so integral to the rates and trends of vegetation succession as to be indistinguishable from the process of succession. Two of the most common functions resulting from insect and pathogen actions in northern Idaho and western Montana are, 1) aslowing of the pace at which early seral species such as ponderosa pine and western larch are replaced by more shade- or competition-tolerant species or 2) acceleration of the pace at which climax composition and structures are reached. In application it is fairly impossible to clearly distinguish between the so-called "disturbance functions" of pathogens and insects and their activities which determine the course and timing of succession. There are dramatic actions such as the mountain pine beetle outbreaks of the 1970's which would seem easily distinguishable as disturbances. But rather than reset the successional time as fires often do, the most common function of the beetle outbreak has been to accelerate the rate at which sites converted to climax subalpine fir or grand fir compositions.

There are often a number of alternative pathways and a range of rates of change. Since these changes do not take place in the absence of pathogens and insects, it is of only academic interest to estimate changes in the absence of pathogens and insects. It is important not to lose sight of the fact that succession is not restricted to the vegetative components of forest communities.

Nonetheless,

For the purpose of this analysis, we use the term *silvical succession* to refer to changes in tree species composition and structure which result from the autecology (relating to site conditions) and synecological interaction of the trees themselves with little influence from pathogens, insects, fires, human activities. For the most part silvical succession is attributable to the relative tolerance of species to lateral competition and shading, seed production and regeneration requirements of species. We also conceptually recognize "seral" and "climax" roles of species as related to site habitat types (Daubenmire 1952). The terms are useful in assessing the potential changes composition and structure in the absence of specific disturbances. These changes indicate a trend toward climax rather than the climax itself (Pfister and Arno 1980).

Pathogen and Insect Succession Function: The outcome of specific actions of pathogens and insects which alter the course or timing of succession.

The succession functions of pathogens and insects also may be among the most predictable of the disturbances in forests, particularly when assessed in intervals of decades or more (Amman and others 1977, Veblen and others 1991, Goheen and Hansen 1993). In this analysis, we examined the relationship between actions of pathogens and insects and the course and timing of succession over a 40-year period.

Objectives and Methods

The primary objective of this analysis is to identify and characterize important successional functions of forest pathogens and insects in Montana and northern Idaho (USDA-Forest Service Northern Region) (Hagle 1992, Hagle and Williams 1995). These efforts are aimed at 1) describing how pathogens and insects affect spatial and temporal patterns of succession, 2) describing current and historic pathogen and insect regimes (the spatial and temporal patterns of pathogen and insect actions), and 3) predicting future successional trends that reflect the role of pathogens and insects.

For each of the insects and pathogens included in the analysis, the important actions and the functions were defined. The "actions" on the part of the pathogen or insect, in conjunction with the physical conditions of the polygons, determine the most likely functions of the pathogen or insect. Physical conditions include, the potential vegetation type (habitat type), cover type, structural stage, elevation, and so on. By focusing only on functions which are expected to be significant at this broad scale, many of the actions of pathogens and insects were eliminated from consideration. When applying this analysis system to other Sections or spatial scales, it may be necessary to add other pathogen or insect functions of the analysis and leave out others to better reflect local conditions or influences.

The analysis consisted of four general phases.

1. measuring 40 years' changes in vegetation

In the first phase a sample was selected to represent a broad range of forest conditions in each of the Sections. The forest planning samples selected in the early 1970's was used to minimize the variability in the year the stands were examined. This provided an essentially uniform interval between the 1935-era forest survey which represented our beginning conditions and the 1974-1975 stand examinations on the same sites. This was consistent with our objective of examining changes over several decades in a variety of site and cover types while minimizing the effect of a variable time interval. We then analyzed successional changes from circa 1935-era to circa 1975-era in polygons covered in surveys from both years. On the basis of the resulting successional stage changes over the 40-year period examined, transition matrices were produced for each polygon class. These matrices show the probability and outcome of transition for 40-years in the absence of fire or tree harvests.

2. discovering relationships between pathogen and insect actions and vegetation conditions/geography

Using the 1975-era stand data, we identified significant pathogen and insect succession functions associated with the represented polygon classes. The types of insect and pathogen actions which lead to significant successional effects, and the conditions under which the actions occurred were examined. From this information, we analyzed the data from 1975-era surveys to assign *Action Probability Index (API)* values (a modified risk or hazard rating system) for each identified action. The polygon classes were then characterized according to their average, range and frequency distributions of pathogen and insect APIs.

3. Associating probable actions of pathogens and insects with changes in vegetation

Pathogen and insect APIs were assigned to polygons based on their 1935-era classes. Pathways were assigned causes according to the pathogens and insects apparently influential in that particular type of transition based on the polygon class APIs and the known types of actions of each pathogen or insect. In some cases the pathway was assigned the cause "silvical succession" implying that the ecological requirements of the trees were most responsible for the successional trends observed. Pathogens or insects were identified as the cause of transition only for polygon classes with the high action probabilities which also had pathways and rates of change which were consistent with the outcomes of the pathogen or insect activity.

4. Translating results to predictions of future trends

The transition matrix with pathways, probabilities, and causes provides a database for development of succession models for the polygon classes included in this analysis. This ability to predict trends is an important part of forest planning efforts. The action probability rating systems developed for each agent and tested against 40 years of actual changes in the sample polygons, provides and ecologically-based risk or hazard rating system for each of the major insects and pathogens. From this not only is the probability of change caused by the insect or pathogen assessed, but the probable ecological outcomes of their actions can be predicted as well. This can be a valuable addition to the risk or hazard rating systems which are designed to predict volume losses or outbreak probabilities but not successional outcomes.

Results

Most our sample of sections M332a and M333d underwent changes in cover, structure, or both between 1935 and 1975. In most cases, pathogens and insects were indicated as having altered the course or timing of succession. Over 90% of hectares in M332a underwent such successional stage changes with 80% of these changes attributable to pathogens and insects. In the sample of M333d, 95% changed successional stage and 75% of changes were attributed to pathogens and insects. From 98 1935-era polygon classes (based on HT group, Cover Type, and structure class) in M332a we observed 266 unique successional pathways, and average of 2.7 types of transitions per polygon class. There were from one up to eight distinct transitions for each polygon class. Of 148 in M333d 743 pathways occurred in our sample; averaging 5 per polygon class with a range of 1 to 27 distinct transitions for each class.

In both sections, a change toward later seral cover types and larger tree structure classes and greater stand density was most prevalent. The most common function of pathogens and insects was to accelerate the change to later seral species compositions. An ecologically important function of many insects and pathogens was to cause prolonged retention of early seral species. This function occurred on 25% and 23%, respectively in M332a and M333d.

Several unique successional pathways were identified which, without human intervention, probably require the actions of a particular pathogen or insect. One such pathway is seen in mature late-seral or climax species cover types with low basal area (structure class 4) on warm, moderate or moist habitat types (groups 3, 4 and 5). When these polygon classes retained the same cover type while remaining in an open or broken canopy condition (also low basal area) for the 40-year interval, stem decay was found to be the only significant agent indicated in maintaining this condition. Similarly, when Douglas-fir or grand fir cover types in seedling/sapling structure remained so for the 40-yr sample period, root disease was the only mechanism indicated. Root disease severity was generally very high under these conditions.

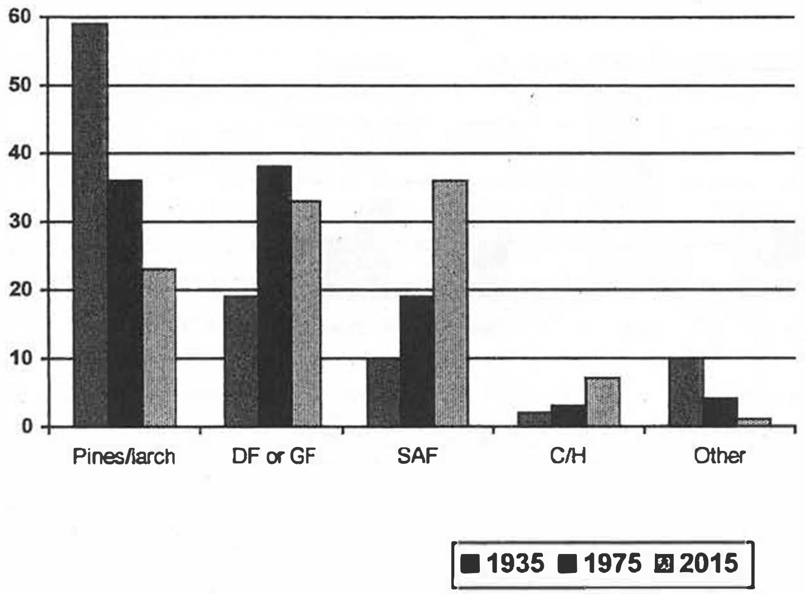
In several types of transitions combinations of pathogens and insects were seen to have opposing effects on forest succession. For example, the combination of root pathogens and mountain pine beetle in mixed ponderosa pine/Douglas-fir stands in HT group 2 resulted in low-density stands with Douglas-fir cover type (SC 4) or small-diameter stands (SC 1 or 2) of ponderosa pine/Douglas-fir cover type. Both transitions are likely due to reduction of the large tree components of Douglas-fir (by root pathogens) and ponderosa pine (by mountain pine beetle) following by regeneration of Douglas-fir, in particular.

Another interesting example was seen in cover or forest types with a significant western larch component in M333d. In HT groups 3, 4 and 5, the moderate to moist and warm habitats, the outcome after 40 years was nearly always a loss of most of the larch component and resulting low canopy density. In this case the combined effects of blister rust, root disease and bark beetles reduced the, usually important, western white pine, Douglas-fir and grand fir components which should have increased the relative importance of western larch. Instead the polygons lost most of the larch component, changing to late seral or near-climax species cover types while remaining in low density conditions. Western larch dwarf mistletoe was indicated as highly involved in the decline of larch.

Trends in cover and structure

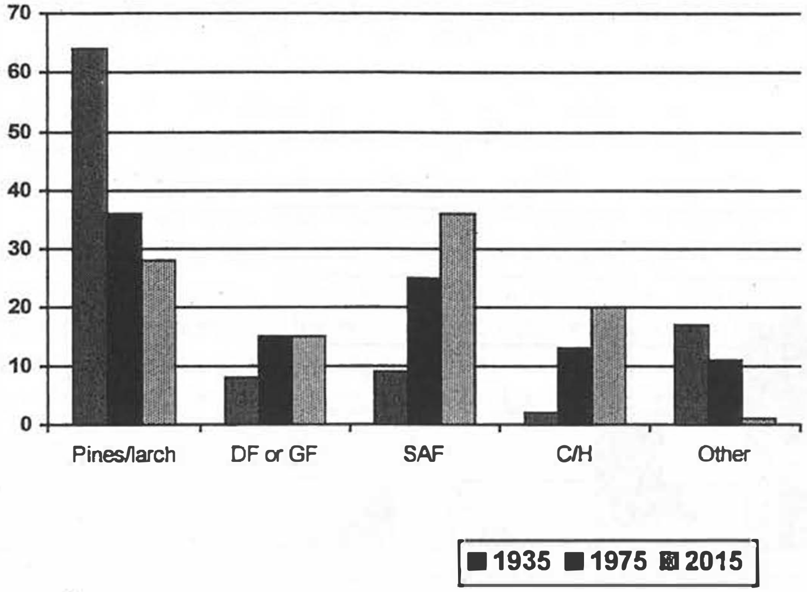
In the sample of section M332a, moderately warm, dry to cool and moist habitat types (groups 2, 4,5 and 7) were best represented. Douglas-fir was the most common single forest type in 1975 as well as the most common component in combination forest types, followed by subalpine fir, lodgepole pine and grand fir (See Figure 1). "Alpine", Douglas-fir, western redcedar/grand fir, ponderosa pine mixture, and lodgepole pine Cover Types were most commonly assigned to these 1975 polygons (ranging from 27% to 13%). The 1935 Cover Types on these same hectares were mostly lodgepole pine, Douglas-fir, or ponderosa pine (ranging from 21% to 14%). Structure class distribution remained fairly consistent between 1935-era and 1975-era. The only notable changes were a drop from 8% nonforested to 2%, and doubling from 10% to 20% in the large tree, well stocked structure class (SC 3) . Pole-size, moderately to well-stocked stands were most common making up 41% of the sample in 1935-era and 40% in 1975-era.

Figure 1: Changes in cover type in M332a from 1935 to 1975 and predicted through 2015.



Habitat types in the M333d sample tended to be cooler types. Most common were HT groups 5, 7 and 9. Forest Types were diverse in 1975, with Douglas-fir slightly more common than others; occurring on 10% of hectares as a single-species Forest Type. Pole size to large tree structure classes were most common in 1975. In 1935-era this sample was mostly large trees with low stocking (SC 4), seedling or sapling size stands or nonforested because of fire. Cover Type shifted from mostly white pine, larch mixtures or nonforested in 1935 (ranging from 35% to 16%) to "alpine", white pine, lodgepole pine, western hemlock/grand fir, or Douglas-fir (ranging from 25% to 11%).

Figure 1: Changes in cover type in M333d from 1935 to 1975 and predicted through 2015.



Pathogen and insect functions: 1935-era to 1975-era In M332a the most significant influences from 1935-era to 1975-era were from root diseases, mountain pine beetle in lodgepole pine, and Douglas-fir beetle (Table1). Unlike M333d, there was little indication of significant changes in the way pathogens and insects have functioned in 1935-era and 1975-era. This is not to say that their functions are not important; they were considered to be the driving force in over 80% of transitions in our sample. Root diseases were the most widespread and influential of the insects and pathogens included in this analysis. All but 2% of polygons were to seen to have some level of root disease effect in 1975-era. The average severity was 3.2, a range of 0-8. Root disease severities were highest in habitat groups 3, 4, 5 and 7 and the Cover Types with the highest average severity were western redcedar/grand fir, western redcedar, western larch mixtures and ponderosa pine mixtures. These were types that were often produced by severe root disease killing Douglas-fir and grand fir components disproportionately, thereby shifting composition toward the later seral or climax species or increasing the retention of other earlier seral species. The overall average root disease severity probably increased from a little less than 3 in 1935-era to the 3.2 measured in 1975-era. This trend appears likely to continue through 2015 when the average may be close to 4.

Both weeding and group-killing types of Douglas-fir beetle actions were fairly common in M332a with 14% of hectares rated as having moderate to high probability of significant influence from Douglas-fir beetle. On habitat types where Douglas-fir is climax, Douglas-fir beetle generally either reduced the density of large-diameter stands or removed enough of the large-diameter trees to cause regression to small-tree structure classes. The Cover Type generally remained Douglas-fir. On the wetter habitat types, the Cover Type generally moved toward more grand fir, western redcedar or western hemlock while the large-tree structure was retained, often increasing in density.

Douglas-fir beetle and root disease were often active in the same polygons and are known to occur in the same individual trees in many situations. The most prevalent function of this combination was to retain relatively more ponderosa pine in affected stands thereby prolonging the early seral stages of succession. Where root diseases acted with little influence from Douglas-fir beetle, they were more likely to cause the structure to regress from large-tree to small-tree structures without changing the cover type.

In habitat type groups 1 and 2, mountain pine beetle in ponderosa pine played an important role in counteracting the advantage root disease would have provided the ponderosa pine component. Root disease alone had a modest tendency to maintain or increase the relative importance of ponderosa pine but where probabilities of mountain pine beetle activity were moderate to high, polygons were more likely to move toward the late seral and climax Douglas-fir cover type while regressing to smaller-tree structures or decreasing in stand density.

Mountain pine beetle largely drove dynamics in lodgepole pine cover types. All but about 20% of hectares in this type underwent transitions in cover or structure that were consistent with outcomes expected from mountain pine beetle activity. Half of the area in our sample that had been identified as lodgepole pine cover type in 1935-era remained lodgepole pine, however, the stands which were pole-size or larger in 1935 generally converted to another Cover Type or lost much of the larger tree component changing to small-tree structures or low density, large-tree structures. Those that converted were identified as mostly "alpine" (subalpine fir, mountain hemlock) or Douglas-fir cover types in 1975.

In 1935-era about 10% of our sample of M332a had a significant component of western white pine or whitebark pine. Less than 1% of hectares in this sample now contains a significant component of either of these species. White pine blister rust and mountain pine beetle were implicated in nearly all of these changes in cover type. Most of the polygons that contained white pine or whitebark pine in 1935-era were in structure classes 1, 2 or 4. Most of these polygons had progressed to late seral or climax species composition by 1975. Cedar or Cedar/Douglas-fir mixtures were most common on lower elevation sites while subalpine fir and mountain hemlock were more likely replacements for white pine and whitebark pine on higher elevation sites. Mountain pine beetle was particularly implicated in the structure class 4 stands, half of which retained a component of whitebark pine in 1975, but none had significant western white pine remaining. Dwarf mistletoes affecting lodgepole pine, Douglas-fir and western larch were important influences in a few situations. The stands most affected were those with a large component of host species and were in early to mid seral stages. Growth suppression and mortality caused by dwarf mistletoes limited stocking density of mature stands while accelerating changes in species composition toward late seral or climax species. Structure classes 2, 3 and 4 had the highest probability of effect by dwarf mistletoes. In these structure classes, lodgepole pine dwarf mistletoe was indicated as a significant influence on succession in 18% of hectares. Douglas-fir dwarf mistletoe was indicated as significant on 16.5%. And larch dwarf mistletoe was significant on 10% of hectares in these structure classes. Douglas-fir dwarf mistletoe was implicated in helping retain the early seral, non-host species in stands, such as ponderosa pine and lodgepole pine. Habitat type groups 2 and 5 were most affected by Douglas-fir dwarf mistletoe. Although larch dwarf mistletoe was implicated in relatively few hectares, the role it played in the decline of mature western larch may have serious long-term ecological impacts through the loss of seed sources and replacement snags for wildlife habitat.

Stem decay effects also appeared to be concentrated in particular polygon classes, affecting a total of 1.7% of sample hectares. Stem decay generally develops as stands reach maturity, becoming more advanced as trees age. Breakage of decay-weakened stems results in loss of individual or small clusters of trees. As expected, although they are fairly host-specific, stem decays had little effect on species composition in stands. They functioned to prevent canopy closure in maturing stands or perpetuate broken canopy conditions (SC 4) in mature stands.

Spruce beetle was also concentrated on certain polygon classes, those with a significant spruce component and structure classes 2, 3 or 4 (mostly SC 3). Over all about 6% of the sample was likely to have been highly influenced by spruce beetle between 1935-era and 1975-era. Spruce beetle outbreaks are usually triggered by windthrow events. Without large expanses of spruce, the outbreaks are generally limited in both time and space. In our sample of M332a, species composition was shifted by spruce beetle outbreaks resulting in later seral or climax species, while the structure classes regressed toward younger, smaller trees or lost canopy density, becoming low-density mature stands (SC 4). These functions were projected to increased to about 15% from 1975-2015.

Western spruce budworm API was high on 22% of hectares in the 1975-era sample. According to polygon classes existing in 1935-era, approximately 30% of hectares probably had high hazard for western spruce budworm defoliation. However, successional pathways were probably affected by budworm on only about 4 % of hectares. The primary impact of budworm defoliation in M332a is growth loss with limited mortality of small trees. Although these affects are likely to have occurred in the study interval, changes in succession due to budworm occurred in relatively few of the defoliated polygons, primarily those with Douglas-fir forest types. The most common type of successional function was to maintain mature stands in low canopy density conditions without altering the species composition

Table1: Section M332a; Influences of pathogens and insects from 1935-era to 1975-era.

Pathogen/insect	Proportion of ha[1]	Primary cover effects (proportion)[2]	Primary structure effects (proportion)
Root Pathogens	.47	Increase climax (.70) Maintain early seral (.23)	Toward immature (.38) Prevent closure (.35) No effect (.24)
MPB, lodgepole	.19	Increase climax (.97)	Toward immature (.35) No effect (.29) Prevent closure (.29)
Douglas-fir Beetle	.14	Increase climax (.54) Maintain early seral (.27)	Prevent closure (.46) Toward immature (.23) No effect (.22)
Douglas-fir Beetle and Root Diseases combined	.12	Increase climax (.54) Maintain early seral (.25) No effect (.22)	Prevent closure (.52) No effect (.23) Toward immature (.21)
WP Blister Rust	.10	Increase climax (.94)	No effect (.53) Prevent closure (.33)
MPB, ponderosa	.06	Increase climax (.78)	Toward immature (.46) Prevent closure (.27)
MPB, white pine	.02	Increase climax (1.0)	Prevent closure (.58) Toward immature (.42)
DF dwarf mistletoe	.04	No effect (.50) Maintain early seral (.44)	Prevent closure (1.0)
LP dwarf mistletoe	.01	Increase climax (.98)	Prevent closure (.98)
WL dwarf mistletoe	.01	Increase climax (1.0)	Prevent closure (1.0)
Stem decays	.03	Maintain early seral (.52) No effect (.39)	Prevent closure (.64) Decrease density (.30)
Spruce Beetle	.01	Maintain early seral (.54) Increase climax (.46)	No effect (.51) Toward immature (.39)
Spruce Budworm	.03	Maintain early seral (.46) No effect (.45)	Prevent closure (.84)

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[1] Proportion of hectares in M332a which are expected to be strongly influenced by the pathogen or insect.

[2] Of the hectares expected to be most affected by the pathogen or insect, the proportion likely to show each successional effect.

Prevalent functions in M333d

The most striking influence in M333d was, not surprisingly, the result of white pine blister rust. The nearly complete conversion of white pine forest types to non-white pine types has been well-documented (Monnig and Byler 1992)(Brown 1996). We saw an 88% decline in Forest Types containing a significant component of western white pine in our sample of M333d. Perhaps for the first time, we have been able to document in some detail, the forest types and structures to which these white pine forests have changed and the resulting influence these changes have exerted on native pathogens and insects. White pine blister rust was distributed throughout most of the white pine forests of sections M332a and M333d by the time of the 1935-era forest survey so our beginning point data reflect conditions of a forest already afflicted to some extent by the disease. In some locations the effects may have been significant, while in most they were probably just beginning to alter forest conditions. Large areas of M333d and the northern portion of M332a (where most of the western white pine is found) had burned in the late 1800 and 1910. The young white pines growing in these recently burned areas were highly susceptible to white pine blister rust and most probably died quickly after rust arrived. By 1975-era most of what had been white pine Cover Type in 1935-era had become subalpine fir, western hemlock/grand fir, or western redcedar/grand fir Cover Types. Douglas-fir was also a highly consistent component of the Forest Types in these polygons.

The most common function of white pine blister rust in either western white pine or whitebark pine was to increase the progress toward late seral or climax species compositions (Table 2). Where this took place, the structure of the stands generally remained stalled in seedling or sapling stages or even move backward from large-tree classes to these small-tree structures. Also an important function of blister rust, occurring on about a third of hectares in M333d, was maintaining other seral components of the stands, especially lodgepole pine and western larch. These species apparently took advantage of the resources made available by the death of white pines and increased their relative importance in the species composition. Where this occurred it was usually accompanied by structure class changes to large-diameter tree class with relatively low stocking density or volume production.

With the decline in large diameter western white pine has come a decline in mountain pine beetle functions in large western white pines. Although there is some activity in younger, smaller white pines in current forests, this is probably quite different from the role mountain pine beetle once played. The abundant large white pine snags created by mountain pine beetle are now a rare occurrence, a loss that may have significant impacts on wildlife species which once utilized the large snags for decades following tree death.

Blister rust and root disease have speculated that the loss of white pine to blister rust has been a precursor to severe levels of root disease on much of the productive “white pine type” (Monnig and Byler 1992, Byler and others 1994, Hagle and others 1994). Evidence from ecosection M333d supports this view. Sites on which white pine blister rust had been a strong influence between 1935 and 1975, were seen to have root disease severities in 1975 roughly equal to the overall average of 4 whereas those which had lodgepole pine cover type in 1935-era, average closer to 3 in 1975-era. When sites with blister rust influence are projected forward to 2015, the root disease severity is expected to decline somewhat to an average of around 3.7, with 40% of conversions to western redcedar/grand fir or, western hemlock/grand fir. This future composition is vastly different from the white pine forests of the past, and increasingly different

Table 2: Section M333d; Influences of pathogens and insects from 1935-era to 1975-era.

Pathogen/ insect	Proportion of ha[3]	Primary cover effects (proportion)[4]	Primary structure effects (proportion)
WP Blister Rust	.43	Increase climax (.76) Maintain early seral (.21)	No effect (.52) Toward immature (.29) Prevent closure (.16)
Root pathogens	.48	Increase climax (.7) Maintain early seral (.24)	Toward immature (.46) No effect (.30) Prevent closure (.21)
WP Blister Rust and Root Disease combined	.30	Increase climax (.75) Maintain early seral (.21)	Toward immature (.44) No effect (.33) Prevent closure (.23)
Douglas-fir Beetle	.04	Increase climax (.64) Increase early seral (.20) No effect (.15)	Prevent closure (.57) Toward immature (.28)
MPB, lodgepole	.03	Increase climax (.63)	Toward immature (.56) No effect (.29)
MPB, ponderosa	.02	Increase climax (.64) Maintain early seral (.36)	Toward immature (.66) Prevent closure (.24)
MPB, white pine	.04	Increase climax (.81) Maintain early seral (.14) No effect (.04)	No effect (.50) Decrease density (.24) Prevent closure (.07)
DF dwarf mistletoe	.02	Increase climax (.60) No effect (.29)	Prevent closure (.97)
LP dwarf mistletoe	<.01	Maintain early seral (1.0)	Prevent closure (1.0)
WL dwarf mistletoe	.01	Increase climax (.92)	Prevent closure (1.0)
Stem Decays	.01	No effect (.50) Increase climax (.38)	Prevent closure (.82)
Spruce Beetle	.02	No effect (.50) Increase climax (.49)	Toward immature (.72) Prevent closure (.15)
Spruce Budworm	<.01	No effect (.59) Maintain early seral (.38)	Prevent closure (1.0)

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[3] Proportion of hectares in M333d which are expected to be strongly influenced by the pathogen or insect.

[4] Of the hectares expected to be most affected by the pathogen or insect, the proportion likely to show each successional effect.

from the Douglas-fir and grand fir mixtures with severe root disease found in our 1975-era sample. Our sample for M333d in 1935 included only 2.7% of hectares with western redcedar/grand fir (code 8 or 9) or western hemlock/grand fir (code 4) in 1975-era these types covered 15.7%. The predicted coverage by these types for our sample area in 2015 is 30%.

The white pine "type" may have crossed its ecological threshold for recovery

With the increase in cedar and hemlock we expect to see future increases in importance of previously unimportant pathogens and insects of cedar and hemlock (Fig. 2). These vast changes suggest the possibility that blister rust has caused the forests of the "white pine type" to be deflected toward previously unknown conditions. The long-term development of forests on these sites may lead to unprecedented forest conditions and communities. Friedel (1991) described range conditions on severely degraded sites as having crossed ecological thresholds, recovery from which would require significant management effort. It is likely that blister rust has created such a situation in which the natural functions of fire and native pathogens and insects will not result in a return to successional pathways which typified these forests at the turn of the century. The longer the delay, the more likely a new trajectory will become as the genetic makeup of forest communities adapts to the new conditions. Punctuated equilibrium, marked by periods of relatively rapid genetic change, has been associated with changes in ecological conditions (Eldredge and Gould 1972). With the decline of white pine resulting in significant changes in available resources for some of the forest species, the conditions may have been met for Milligan's model for punctuated evolution mediated by "slight changes in the complex distribution of resources" (Milligan 1986). The future on these sites may be very different from the "natural range of variability" model we often target as acceptable forest conditions.

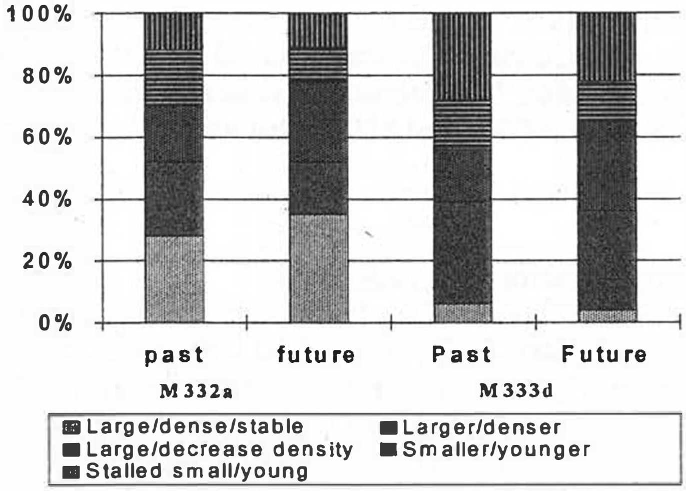
Impending bark beetle outbreaks in Douglas-fir and grand fir forests smaller proportion of hectares with 1935-era white pine Cover Types converted to mixed stands containing large proportions of grand fir and Douglas-fir. This conversion has brought with it increases in the significance of root disease and some bark beetles such as Douglas-fir beetles and fir engraver beetles (*Scolytus ventralis*). The extensive Douglas-fir beetle outbreak the northwestern portions of M333d (on and near the Idaho Panhandle National Forests) in 1998 and is evidence of this trend. Although the distributions of root pathogens have probably been little-affected by the increase in abundance of host trees, the severity of the diseases have probably increased dramatically in habitats which were once occupied by white pine forests. Douglas-fir and grand fir were present in most of these forests in 1935-era as a part of the mixture but they were apparently only infrequently abundant enough to be the Forest Type. In our sample of M333d, 6.4% of hectares had been identified as having Douglas-fir and 2.5 % as grand fir (in mixture with western redcedar or western hemlock) Cover Types in 1935. By 1975-era Douglas-fir and grand fir Cover Types covered 10.7% and 14.1%, respectively.

Suspended succession

On 28% of hectares, severe root disease effectively held stands in a state of suspended succession. This function, identified as "stalled structure", is one in which seedling/sapling stands of Douglas-fir, grand fir or subalpine fir were seen to remain so for the 40-yr interval of this analysis. In the context of rangeland succession, Laycock (1989) used "suspended stages of succession" to describe plant communities that remain almost unchanged in species composition for relatively long periods. In our case, the suspended stage of succession is also identified by an unchanging structure class in what would ordinarily be considered a short-term structure on such productive sites. This function (stalled structure with essentially unchanging cover type) was produced under what appear to be natural conditions. These features are commonly referred to as root disease patches. Other, less obvious, cases of suspended succession were seen in the retention of early seral species on many sites (22% of hectares). Again, this was generally due to the actions of root pathogens and bark beetles that kill mid- to late seral tree species.

Trends from 1935-era to 1975-era; how did we get to 1975-era conditions Most of the changes in forest conditions in our sample from 1935-era to 1975-era were strongly influenced by pathogens and insects. Their most important functions over this period were to push toward climax species composition and reduce or prevent canopy closure (Fig 3). On 26% of hectares in M332a and 21% in M333d where they had moderate to high probabilities, they effectively stalled structure development, maintaining forests in early structure classes for 40 years. This role was most evident on the most productive habitat types. A high percentage (62% in M332a and 58%in M333d) of pathways were identified as likely unique to those produced by pathogens and insects. As such, they represent some of the important ways in which pathogens and insects maintain ecological diversity. Stalled structure development is a good example of this type of pathway, in a 40-year time step the polygon is seen to have remained in, or returned to a seedling/sapling class.

Figure 2: Past and future succession functions of insects and pathogens in sample polygons from M332a and M333d.



White pine blister rust-influenced pathways were mostly unique to this agent. As an introduced pathogen, it has carved a unique niche in forests of Section M333d. The rapid transition of young, predominantly white pine stands to Douglas-fir, grand fir and western redcedar is well documented in this analysis. The subsequent loss of mature, closed-canopy western white pine successional stages has greatly altered the composition of much of northern Idaho and western Montana. Mountain pine beetle in western white pine once played an important role in the ecology of forests in M333d. It has shared the limelight with white pine blister rust since the early 1930s. In our sample of this ecosection, 1935-era white pine forest type in large tree, closed canopy conditions all changed to other forest types or structure classes. Generally the changes were to more climax species compositions while remaining in or returning to large tree, closed canopy structures by 1975-era. About 31% of the hectares in habitat group 5 (the largest group in M333d) which had white pine forest type and large, closed canopy structures, had changed to pole-size or large tree structures with low basal area, or to non-forest. In habitat type group 7, all polygons changed from white pine to other species and 57% became pole-size stands or large-tree stands with low basal area.

Habitat type groups 5, 2, 7, and 4 were especially well-represented in the sample of M332a and Douglas-fir forest type was particularly common in both the 1935-era and 1975-era surveys, representing about 20% of the sample hectares in each time period. This was generally not because places which had DF forest type remained so; but mostly a result of areas moving into and out of DF forest type at about the same rate. Most of the new DF forest type came from polygons which previously had PP, or DFPP forest types while most the migration out of DF forest type was into either C DF or various combinations which included AF. The overall result was a general movement toward more climax forest types. Both root disease and Douglas-fir beetle were important in moving forest types from Douglas-fir and Douglas-fir mixtures into late seral or climax compositions.

Current Trends:

Projecting the Sample Polygons into the Future

If we assume that pathogens and insects will react in similar ways to a given forest condition in the second forty years as they did from 1935 to 1975, and if we assume the sample represents polygons which remain unharvested and unburned form 1975 to 2015, then a rough estimate of current trends is possible. This estimate provides a glimpse into the probable future of the majority of land in Sections M332a and M333d that will neither be harvested nor burned before the year 2015.

M332a: Pathogen and insect functions 1975 to 2015

Based on the APIs and 1975-era and the types of changes observed in polygon classes represented in 1935 to 1975 transitions, root diseases and Douglas-fir beetle are expected to be the most significant influences from 1975 to 2015 (Table 3). Mountain pine beetle is expected to be much less common, dropping from 19 to 9% of hectares. Blister rust influence has declined with the loss of white pine to the disease and to mountain pine beetle attacks. Spruce beetle is expected to increase somewhat to about 6% of hectares. Although this number is small, the effects are typically concentrated on contiguous areas, so a number of locally-significant outbreaks are likely to occur. Stem decays are also expected to undergo a slight increase by

2015. As more forests enter later seral and maturing tree classes, these diseases are expected to continue their increase.

There are a couple of changes in function trends expected in polygons with the greatest influences from pathogens and insects (Fig.1). The portion of the sample area on which pathogens and/or insects cause an increase in early seral species is expected to rise from about 9% in the first 40 years to closer to 16% of hectares from 1975 to 2015. Also, because of the greater proportion of the sample area which already has climax or near climax species composition, the pathogens and insects are expected to have less influence on cover type changes in the second 40 years, with 39% remaining unchanged (compared to 20% from 1935 to 1975).

Table 3: Expected trends; Influences of pathogens and insects in Section M332a from 1975-era to 2015-era.

Pathogen/insect	Proportion of ha[5]	Primary cover effect (proportion)[6]	Primary structure effect (proportion)
WP Blister Rust	<.01		
Root Pathogens	.43	Increase climax (.6) Maintain seral (.2)	Toward immature (.3) Prevent closure (.3) No effect (.3)
Douglas-fir Beetle	.18	Increase climax (.6)	Prevent closure (.4) No effect (.3)
MPB, lodgepole	.09	Increase climax (.9)	No effect (.7)
MPB, ponderosa	.05	Increase climax (.8)	Toward immature (.5) Prevent closure (.3)
MPB, white pine	<.01		
DF dwarf mistletoe	.04	No effect (.5) Maintain seral (.4)	Prevent closure (>.9)
LP dwarf mistletoe	<.01		
WL dwarf mistletoe	<.01		
Stem decays	.04	No effect (.5) Maintain seral (.4)	Prevent closure (.9)
Spruce Beetle	.06	Increase climax (.9)	No effect (.9)
Spruce Budworm	.03	No effect (.6)	Prevent closure (>.9)

With the changes toward more climax composition, the trend toward larger trees is expected to be more pronounced in the second 40 years as fewer stands are retained in the small tree classes. A decline from 46% to 28% of hectares exhibiting these functions is expected (Fig.2). Relatively open canopies are expected in much of the large- tree classes, caused by continued pathogen and insect-caused mortality. This function is expected to increase in frequency from 21% in the period from 1935 to 1975 to 40% from 1975 to 2015.

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[5] Proportion of hectares in M332a which are expected to be strongly influenced by the pathogen or insect.

[6] Of the hectares expected to be most affected by the pathogen or insect, the proportion likely to show each successional effect.

Trends in M332a, 1975-2015

From 1935-era to 1975-era, 10 percent of the sample hectares remained in the same Cover Type and structure classes. On the basis of the polygon classes in the 1975-era sample, 20 percent are expected to remain in the same Cover Type and structure class through the year 2015. These polygons were classified as climax or near-climax species composition with large trees and closed canopy structure in 1975-era. The next largest category (8% of hectares) are polygons which are expected to remain in climax or near climax species composition while canopy closure is prevented (ending in structure class 4 in 2015). In the previous 40 years, only 3 percent of the sample hectares underwent this type of change, primarily because so few polygons were classified as late seral cover types.

Overall, 45% of the 1975-era sample is expected to remain in late seral or climax Cover Types and another 24% are expected to continue to increase the relative proportions of late seral species sufficiently to classify as a later seral Cover Type. Early seral species are expected to be maintained as the Cover Type on about 31% of hectares. This represents the continuation of a significant trend toward increasingly uniform species composition in the forests, signaling a loss of beta diversity through the loss of early seral forests.

Approximately half of the hectares are expected to remain in the same structure, generally a mature, well-stocked condition or to grow into this structure class by 2015. One fourth is expected to be in large-tree structure with pathogens and insects preventing the canopy from closing. About one fifth of hectares is expected to remained stalled in early structure classes (seedling/sapling or pole) for another 40 years or to regress from larger tree structures to small/young tree structures. This proportion is similar to that observed from 1935-era to 1975-era.

Looking only at habitat type groups (groups 3, 4, and 5) in which trees are expected to reach large-tree sizes, the trend is even more pronounced. Of the hectares which were in seedling/sapling or pole structure classes in 1975-era, somewhat more area is expected to remained stalled (33%) through the year 2015 than that expected to progress to large tree, closed canopy structures (26%). The converse was true from 1935-era to 1975-era in which 25% of these small-tree structure classes remained stalled and 50% progressed to large-tree, closed canopy structures. The stands that stalled from 1935-era to 1975-era are more likely to continue to stall for another 40 years (53%) than are those that did not remain seedling/sapling or pole stands throughout the previous 40 years (17%).

The net result of these changes would be a continued increase in the relative proportions of grand fir, subalpine fir, and cedar/grand fir Cover Types. After a fairly dramatic increase from 1935 to 1975, Douglas-fir Cover Type is expected to decline. This will likely result from root disease and Douglas-fir beetle activity. A continued decline in proportions of ponderosa pine and lodgepole pine Cover Types is expected.

Structure class 0 (non-stocked) is expected to continue to be reduced unless regeneration harvests or fires increase. After a small increase in structure class 1 (seedling/sapling) in the first period, a decline is predicted as forests grow into class 2, 3 or 4. Structure class 2 (pole, moderately to well-stocked) may decline somewhat as larger tree classes are achieved. Structure class 3 (large-tree, closed canopy) is expected to continue to increase somewhat. Structure class 4 (large-tree, broken canopy), which had declined somewhat from 1935 to 1975, is expected to increase for the next few decades as stands in structure classes 2 and 3 are affected by pathogens and insects which prevent the development of closed canopies (Fig. 2).

M333d: Pathogen and insect functions 1975 to 2015

Based on the APIs and 1975-era and the types of changes observed in polygon classes represented in 1935 to 1975 transitions, blister rust and root diseases are expected to continue to be the most significant influences from 1975 to 2015 (Table 4). In addition, Douglas-fir beetle is expected to increase dramatically. Mountain pine beetle in lodgepole pine is also expected to increase substantially in the next few decades. Douglas-fir dwarf mistletoe and stem decays are expected to expand and intensify during these decades as well. Mountain pine beetle in ponderosa pine is expected to increase for awhile as young pines reach maturity. A small increase is also expected in larch dwarf mistletoe as the small remaining larch component continues to mature. Western spruce budworm is also expected to increase as the Douglas-fir, grand fir and subalpine fir hosts grow increasingly multi-storied. This is particularly likely on and near the Clearwater and Lolo National Forests where outbreaks have occurred in the past.

The overall effect of pathogens and insects in the most-affected polygons, those with moderate to high influences from at least one pathogen or insect, appears to be surprisingly stable. In comparing the major functions from the first 40-years (1935 to 1975) to the second 40 years (1975 to 2015), the changes, proportionally, in trend are relatively minor. In the first period 37% of hectares were seen to be stalled in young tree structures or to regress from large tree to small tree structures. For the second period, 37% of hectares are expected to follow this trend (Fig. 2). A slightly smaller proportion, 40% compared to 44% are expected to move into or remain in the large-tree, closed canopy structure class. Similarly, the same proportion of hectares is predicted to retain or increase seral species composition as did in the first 40 years (34%). These are a fairly remarkable outcomes considering there have been great changes in tree species composition and in the relative importance of the various pathogens and insects. It appears that much of the role played by white pine blister rust in the first 40 years will be assumed, in the broad sense, by root pathogens and bark beetles.

Trends in M333d; 1975 to 2015

In M333d, cover trends in species composition are toward more stability with approximately 80% of stands either progressing toward more climax species or remaining stable in largely climax species composition. Less than 20 percent of hectares are expected to maintain early seral species compositions. The trends in structure are striking in this Section, however, with about sixty five percent of hectares expected to have low canopy conditions, remain stalled in small, young tree structures for the 40-yr period or move into small, young tree structures by 2015 as a result of pathogen and insect activities. Only about one third of stands are expected to continue to grow into larger tree, closed canopy structure or remain stable in these structures.

The net result of these changes would be a continued increase in the relative proportions of grand fir, subalpine fir, western hemlock/grand fir and cedar/grand fir Cover Types. Also expected is a fairly dramatic decline in Douglas-fir; back to about 1935-era levels. This will likely result from root disease and Douglas-fir beetle effects. A continued decline in proportions of western white pine, ponderosa pine and western larch Cover Types is expected, though less dramatic then the decline of these species in the first 40 years. Lodgepole pine increased in the first 40 years but as it reaches maturity, mountain pine beetle depredations are expected to cause a significant decline in the period 1975 to 2015. Recent mountain pine beetle on Avery and Superior Ranger Districts are probably part of this predicted trend.

Structure classes 0 (non-stocked), and 1 (seedling/sapling) are expected to continue to decline. Structure class 2 (pole, moderately to well-stocked) may decline somewhat as larger tree classes are achieved. Structure class 3 (large-tree, closed canopy) is expected to continue to increase somewhat. Structure class 4 (large-tree, low density and broken canopy), which had declined fairly dramatically from 1935 to 1975, is expected to increase for the next few decades as stands in structure classes 2 and 3 are affected by root disease and bark beetle outbreaks.

Table 4: Expected trends; influences of pathogens and insects in Section M333d from 1975-era to 2015-era.

Pathogen/ insect	**Proportion of ha**[7]	**Primary cover effect (proportion)**[8]	**Primary structure effect (proportion)**
WP Blister Rust	.35	Increase climax (.6)	No effect (.4) Prevent closure (.4)
Root pathogens	.66	Increase climax (.6)	Toward immature (.4) Prevent closure (.4)
Douglas-fir Beetle	.18	No effect (.5) Increase climax (.40)	Prevent closure (.6) Toward immature (.3)
MPB, lodgepole	.12	Increase climax (.7)	Toward immature (.6)
MPB, ponderosa	.08	Increase climax (.9)	Toward immature (.5) Prevent closure (.5)
MPB, white pine	.03	No effect (.7)	Prevent closure (.9)
DF dwarf mistletoe	.19	No effect (.6)	Prevent closure (>.9)
LP dwarf mistletoe	>.01	Maintain seral (>.9)	Prevent closure (>.9)
WL dwarf mistletoe	.03	Increase climax (>.9)	Prevent closure (>.9)
Stem Decays	.08	No effect (.6)	Prevent closure (.9)
Spruce Beetle	.02	No effect (.7)	Prevent closure (.5) Toward immature (.4)
Spruce Budworm	.04	No effect (>.9)	Prevent closure (>.9)

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[7] Proportion of hectares in M333d which are expected to be strongly influenced by the pathogen or insect.

[8] Of the hectares expected to be most affected by the pathogen or insect, the proportion likely to show each successional effect.

Landscape and forest planning

This analysis was intended to provide a means to study and assess the functions of tree pathogens and insects in forest ecosystems, and to assess past and current trends in those functions. We have reported herein on both aspects of this project. The extensive database, which we amassed for this analysis, also was designed to provide information useful for forest and landscape planning. The action probability indices reflect the relative probability of significant activity for each of the studied pathogens and insects. These can be calculated individually for stands with standard (R1-Edit) stand-level data or they can be applied as average, range or frequency statistics by polygon class. Polygons can be classified in any of a number of ways with the disease and insect statistics calculated according the specified classification scheme. This approach was taken because there is currently little consistency among National Forests and other forest land owners in the site and stand classification schemes utilized in local planning efforts. There are ongoing efforts within the US Forest Service and other groups to produce a broadly accepted vegetation classification system. These efforts are of critical importance the efficiency and across- border compatibility of forest and landscape planning efforts.

Interpreting the indices; alternatives for portraying significance and trends

The API's, like risk indices, are subject to interpretation. High index values refer only to relative susceptibility of stands to effects from the pathogen or insect (or combination). To understand the probable outcome of an outbreak, should it occur, and the relative probability of the outbreak occurring, results of the successional analysis by polygon classes should be consulted. Successional effects associated with each of the pathogen/insect/polygon class combinations are applicable to forest and landscape-level planning. They provide a means to predict trends in vegetation cover and structure as well as pathogen and insect APIs for the majority of area on most National Forest which are not expected to be harvested or burned in the next few decades.

Where it is more desirable to base assessment on polygon classes, such as in the case of remote-sensed data, the statistics representative of pathogen and insect activities in polygon classes will provide general trends according to the abundance and distribution of polygon classes within an analysis area. The statistics from each of the ecoregion sections examined in our analysis represent the range and frequency of pathogen and insect API's. The transition analysis for each polygon class provides relevant trends for each class within the ecoregions. For landscape and Forest-level analyses, GIS technology is used to assign the ecoregion section identity to polygons and apply the appropriate statistics to each polygon.

Stand and Landscape models

The use of geographically explicit data from two time periods resulted in generation of considerable data on transitions during the 40-year period. These data represent a large range of conditions within each of the major ecoregion sections in the Northern Region and may represent the first substantial database to be used in succession modeling. Most, perhaps all, landscape models currently in used in the Northern Region are based on limited data, relying heavily on professional judgment for succession pathways and probabilities. As a substantial effort to document successional changes, data from this analysis can be a start toward validation of existing landscape models such as CRBSUM (Keane and others 1997) which was the primary vegetation model used in the Columbia River Basin analysis and SIMPPLLE (Chew 1995), a stand-based succession model demonstrated in the Bitterroot Ecosystem Management Demonstration Project and under development for other areas in the Northern Region.

The successional pathways and probabilities derived from the present analysis were used to calibrate the North Idaho variant of the Forest Vegetation Simulation (FVS) model (Stage 1973, Wykoff and others 1982) for unharvested and unburned stands. The Dwarf Mistletoe Impact model (From Jane 19--) and the Western Root Disease model (Stage and others 1990, Beukema and others 1995) of FVS are used in conjunction with the base FVS (growth and regeneration models) for these projections of the 1975-era stand data used in the present analysis. Using these FVS capabilities, we projected stands simulating the effects of dwarf mistletoes, root pathogens, bark beetles and white pine blister rust. Most landscape models have annual or decade time steps rather than the 40-year time step represented in our analysis. The 10-year time steps resulting from the calibrated FVS outputs can provide a reasonable prediction of changes during the intervening years.

The outcomes from these 10-yr intervals from FVS projections were then used to construct arrays of polygon classes, successional pathways and decadal transition probabilities for each ecoregion section. Efforts are underway, in collaboration with the Flathead National Forest, to enter these data into the Vegetation Dynamics Development Tool (VDDT) (Beukema and Kurz 1995) which will allow us to compare our outcomes with those of the pathogen- and insect-designated pathways in the CRBSUM model. This process has constituted a significant project in itself and will be reported elsewhere. However, FVS users in the Northern Region may want to note that we can now provide additional tools to enhance their FVS projections. Files of "addkeys", modifiers for the Western Root Disease and Dwarf Mistletoe Impact models, are now available for improving the performance of these models based on the habitat type and initial root disease severity of projected stands.

General ecological and management implications

Unlike the outcome of most fire-induced changes, the most significant functions of pathogens and insects result in increasing the proportion of climax tree species in forests. This outcome may be considered undesirable in most situations in ecosection M332a and M333d where low proportions of early seral species such as pine and western larch are already a concern. In some situations, however, the pathogens and insects do favor the relatively resistant early seral tree species by killing Douglas-fir and grand fir, often later seral or climax on these sites. This function is probably important in habitat type groups 2, 3, and 7, in particular. Ponderosa pine, western larch and lodgepole pine are the main beneficiaries of this type of function.

Pathogens and insects also function broadly to reduce stand density and prevent canopy closure. Although this can translate to heavy impacts on timber production, the multi-storied structure that generally results when canopy is reduced, may be viewed by wildlife biologists and the viewing public as a desirable stand trait.

Recruitment and long-term retention of old growth, by most current definitions, may be difficult or impossible to achieve on many sites and with some tree species. In most cases this is not because of unusual or unexpected insect or pathogen activities but rather is a matter of course in natural succession where insects and pathogens respond to agreeable stand or site conditions. A most unfortunate exception to this are old growth western white pine forests which were devastated, directly or indirectly, by the threat of the exotic pathogen, *Cronarium ribicola*, the cause of white pine blister rust. Recovery of the white pine forest type from this disease is unlikely, leaving the future of these ecosystems uncertain. Worldwide trade brings to our seaports continual threats of additional exotic introductions, which have the potential for similarly devastating effects. It is important not to underestimate the ecological importance of existing and potential exotic introductions.

The activities of pathogens and insects occur to some degree in all stands, on all acres of the forest, each year. Most of the effects are cumulative over the course of forest development and throughout the process of forest succession. As such there are limited opportunities to substantially alter the functions of pathogens and insects. Nearly all successful manipulation of pathogen or insect activities happens through vegetation management. Alter the condition of the vegetation and you will alter the opportunities for vegetation-dependent pathogens and insects.

With foresight, careful analysis of trends and planning accordingly, we can maximize our effectiveness. The most obvious outbreaks of diseases and insects are not necessarily the most damaging from an ecological standpoint. It is important to focus on the outcomes of pathogen and insect actions rather than the pathogens or insects themselves, if we are to identify the best times and places to concentrate our efforts. Processes developed through this project can be employed to generate more meaningful forest plans, to analyze alternative actions, and to more accurately communicate those alternatives to the various publics served by private and public forest mangers.

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WORKSHOP

Nursery and Seed Orchard Insects and Diseases

Moderator: Bob James

Cone Beetle Behavioral Chemicals in Western North America

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Recent research has revealed several behaviorally active chemicals for beetles in the genus *Conophthorus*. Among these are pityol, an attractant for male cone beetles produced by female beetles, and conophthorin, an inhibitor of male response to female cone beetles, produced by males or both sexes, depending on the species. Alpha-pinene, produced by host pines, has been shown to be an effective synergist for the attraction of pityol to male beetles in eastern cone beetle species. Three generalist repellents, 2-hexenol (a "green leaf volatile"), verbenone (produced by cone beetles and other scolytids) and 4-allylanisol (produced by a wide range of plants), are also considered promising for use in cone beetle pest management programs. In a series of studies we tested the responses of cone beetles (*Conophthorus conicolens* from *Pinus pseudostrobus, C. ponderosae* from *Pinus ponderosa* and *Pinus monticola*, and *C. teocotum* from *Pinus teocote*) to various combinations of these chemicals. The most promising of these chemicals have been prepared as sprayable, microencapsulated formulations for direct application to cones.

Test sites were located at Foresthill Clone Bank near Foresthill, California (*Pinus ponderosa/Conophthorus ponderosae*), a seed orchard in Coeur d'Alene, Idaho *(Pinus monticola/Conophthorus ponderosae*), an unmanaged stand near Paracho, Michoacan (*Pinus teocote/Conophthorus teocotum*) and a managed seed production area near San Juan Nuevo Parangaricutiro, Michoacan, Mexico (*Pinus pseudostrobus/Conophthorus conicolens*). Baits were deployed in yellow Japanese beetle traps placed in the upper crowns of the trees, one trap/tree, with a spacing of at least 15 meters between traps. Sprays of microencapsulated 4-allylanisol were applied directly to cones at Foresthill Seed Orchard in 1997 and 1998. In 1999, microencapsulated sprays of three putative inhibitors were applied to cones in both California and Mexico.

Conophthorin was the only behavioral chemical that elicited a consistent response across the entire genus *Conophthorus*. In all cases, conophthorin effectively shut down trap-catch of males in pityol-baited traps. Pityol was an effective attractant for most of the species in the genus, but its activity was greatly synergized by the addition of various other components, depending on the species involved. On the other hand, some of the synergists acted as repellants or as behaviorally neutral components for other species. In 1997, the application of microencapsulated 4-

allylanisol provided significant protection when applied to cones of *Pinus ponderosa*. Results from 1999 corroborated the efficacy of 4-allylanisol for cone protection against attack by *C. ponderosae*, but not for *C. coniperda*, *C. coniolens*, or *C. teocote*.

Trap-out of Ponderosa Pine Cone Beetle to Reduce Conelet Abortion in Willamette Valley Ponderosa Pine

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A semiochemical mass trapping program in Canada and the southeast U.S. has been shown effective in catching large numbers of the white pine cone beetle, *C. coniperda*, which uses the same pheromone component as the ponderosa pine cone beetle, *C. ponderosae*. However limited funding and the need to treat whole seed orchards has prevented evaluation of the ultimate measure of efficacy, the reduction of damage to cones. The small, scattered stands of ponderosa pine in the Willamette valley provide a unique opportunity to run a well replicated project to determine if the "trap-out" method will reduce beetle populations enough to significantly reduce conelet damage as well.

The objectives of this study are: (1) to determine if mass trapping over several years (1997-1999/2000) reduces *C. ponderosae* populations in isolated ponderosa pine stands; and (2) to determine if *C. ponderosae* population reductions result in reduced abortion of early second year conelets.

Entire small stands or groups of isolated ponderosa pine are used as treatment plots so that there will be little chance of inflight from untreated trees. Treatments are: 1) untreated check; and 2) trap-out, using pityol and alpha-pinene. Six replicates were treated in 1997, eight in 1998, and seven in 1999. Baits and traps are placed at a spacing of approximately 10/acre (one trap per every three or four trees), and positioned in the mid- to upper-crown using a line gun.

Traps are checked and beetles collected every 2-3 weeks throughout the flight period. To evaluate cone damage, at least 50 randomly selected cones will be collected per plot. Cones are picked from at least three trees per plot and at least three branches per tree. Cones were rated as mature, aborted due to *C. ponderosae*, or aborted due to other causes.

The mean number of beetles captured per trap were: 199 in 1997; 91 in 1998; and 113 in 1999. So, while trap catch dropped substantially from 1997 to 1998, the number of beetles captured was not further reduced in 1999. In both 1997 and 1998, the mean percentage of healthy cones in control and trap-out plots were 1% and 2%, respectively. There were no statistically significant differences either year.

Extremely small cone crops occurred all three years of this study, which resulted in *C. ponderosae* damaging almost all cones regardless of treatment. Surveys of first year conelets show that there will be a large cone crop in 2000. If funding is available to continue the trap-out study one more year, this would be an opportunity to achieve definitive results on the efficacy of trap-out as a control method for cone beetles.

Duff Management to Control the Douglas-fir Cone Gall Midge in Seed Orchards

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The Douglas-fir cone gall midge, *Contarinia oregonensis* Foote, is a significant pest of Douglas-fir cones and seeds. Left uncontrolled this insect can virtually destroy an orchard seed crop, and therefore, any opportunity to increase the productivity of our tree farms through genetic improvement. Our current control arsenal contains four pesticides currently labeled for use. Guthion, dimethoate, and MSR are highly toxic organophosphates. They will be under intense scrutiny by the EPA as it proceeds with implementation of the Food Quality Protection Act and so it unclear how long we will be able to use these chemicals. Asana XL, a pyrethroid, is considerably less toxic, and may be the only chemical left in our arsenal to treat the midge. What is becoming increasingly clear, is that we must move toward integrated pest management; not only because the EPA will guide us there, but because it is the environmentally correct thing to do.

Midge larvae drop to the ground following the first rains in the fall, they overwinter in cocoons in the litter, primarily in spent pollen cones. The objective of the duff management work has been to attempt control by removing habitat conducive to overwintering midge. A previous study assessing manual duff removal over a three year period showed a 55% reduction in emerging midges. A follow-up study of several duff treatments showed reduced midge emergence when pollen buds were removed.

The objective of this study is to evaluate adult midge emergence between duff management treatments completed in an operational setting, using equipment designed to remove duff.

Three treatments were replicated 10 times in a completely randomized design: 1) control; 2) flail only, using a Weed Badger; 3) flail and vacuum, using Weed Badger and Rac-O-Vac Turf Sweeper. Each replicate consisted of 2 trees. Treatments were applied on 30 September 1998 at the Bureau of Land Management's Horning seed orchard. Effectiveness of the machinery was assessed by counting the number of 1998 pollen cones in four, 1-square foot litter samples immediately after treatment. Treatment efficacy was evaluated by monitoring adult midges in eight emergence traps per replicate from 5 April through 10 May 1999.

The number of pollen cones were significantly reduced in the flail and vacuum treatment compared to the control or flail only treatments. Since flailing chops up the duff, but does not remove it from the site, these results are consistent with what would be expected in an effective treatment application. Analysis of midge emergence (females only, males only, and total midge) showed statistical differences between all three treatments; with controls having the highest numbers, flail only intermediate, and flail and vacuum the lowest number of midge emerging. Midge emergence was reduced about 75% in flail and vacuum plots compared to the controls. These results show that duff removal has excellent potential as one component of an integrated pest management approach to midge control.

FQPA and Minor Use: An Update

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The Food Quality Protection Act (FQPA) of 1996 has new standards for the reregistration process of pesticides. Under FQPA the Environmental Protection Agency (EPA) established new science policies to implement the law. One of the most significant policies is exposure assessment dealing with cumulative risk and aggregate exposure. This process combines the risk from all registered or proposed uses of an active ingredient. This approach could lead to the loss of 'minor use' pesticides critical to natural resource management. In order to retain these pesticides, the forest community needs to take a more proactive role in the reregistration process. To help in this regard, the Forest Service has established an FQPA Committee composed of pesticide specialists and chaired by Jesus Cota.

This Committee will track the reregistration process, provide chemical profile use data to EPA, and promote coordination with and between external partners and EPA. This process should increase EPA awareness of the importance of pesticide use in natural resource management. The following table is an initial effort by the FS-FQPA Committee to prioritize pesticides used in forestry that are scheduled for EPA risk assessment.

Priority EPA Risk Assessment Pesticides Used in Forestry

Common Name	Class	Mode of Action	Primary Use/Remarks
Acephate	Organophosphate	I	Contact & systemic poison.
Benomyl	Carbamate	F	Systemic foliar; need for seed treatment; *Botrytis & Fusarium*.
Captan	B1/B2 Carcinogen	F	Protectant-eradicant seed treatment, *Botrytis & Fusarium*.
Carbaryl	Carbamate	I	Broad spectrum, long residues, contact & stomach poison; bark beetle control.
Chlorothalonil	B1/B2 Carcinogen	F	Used in progeny testing.
Chlorpyrifos	Organophosphate	I	Broad spectrum stomach poison. Treat seeds.
Coumaphos	Organophosphate	I	**RUP.** Systemic, for livestock. Controls grubs, flies, lice, ticks, mites & others.
Desmedipham **Phenmedipham**	Carbamate B1/B2 Carcinogen	H	Selective postemergence in nursery beds.
Diazinon	Organophosphate	I/A/N	**RUP.** May be absorbed through the skin. Used on seeds, plants & animals (plague vectors).
Dichlorvos (DDVP, Vapona)	Organophosphate	I/A	Fumigant, stomach & contact poison. Used in insect monitoring traps.
Dimethoate	Organophosphate	I/A	Contact, residual & Systemic; used in nursery.
Fenoxycarb	Carbamate	I	Broad spectrum insect growth regulator.
Fenthion	Organophosphate	I/A	Contact and stomach poison. Long residual.
Iprodione	B1/B2 Carcinogen	F	Systemic; controls *Botrytis* spp.
Malathion	Organophosphate	I/A	Used in nursery & seed orchards.
Oxydemeton methyl (MSR, Metasystox-R)	Organophosphate	I/A	**RUP.** Systemic with contact & stomach action. Can be injected into trees & soil.
Phorate (Thimet)	Organophosphate	I/A	**RUP.** Fumigant, systemic and contact action. Used in plantations and seed orchards for pine-tip moth control. May stimulate plant growth.
Phosmet	Organophosphate	I/A	Contact poison.
Thiophanate-methyl	Carbamate B1/B2 Carcinogen	F	Broad spectrum systemic; used in nursery & greenhouses.
Trichlorfon (Pronto)	Organophosphate	I	Contact & stomach poison. Does not control aphids & mites.
Vinclozolin	B1/B2 Carcinogen	F	Controls *Botrytis, Sclerotinia, Monilia* spp & others.

A= Acaracide; F= Fungicide; H= Herbicide; I= Insecticide; N= Nematicide; RUP= Restricted Use Pesticide.

Fumigation and Other Approaches to Management of Soilborne Disease Problems in Nurseries

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In many nursery operations, diseases caused by soilborne pathogens have been effectively managed through preplant soil fumigation. Because methyl bromide has been a key ingredient in the standard fumigation mix and because it will be unavailable in the near future, there is a need to identify efficacious alternatives. The strawberry industry in California is one of the largest users of methyl bromide for soil fumigation and so has devoted the most resources to testing alternative treatments. Because the other fumigants under consideration are broad spectrum in their activity, the results obtained in strawberry nurseries are likely to be applicable to other commodities as well. Our results have shown that chloropicrin at 250 pounds/acre and chloropicrin plus telone (35:65) @ 400 pounds /acre are comparable to the standard methyl bromide:chloropicrin combination (2:1 @ 350 pounds/acre), in terms of their effect on *Verticillium dahliae* (cause of Verticillium wilt). All three treatments reduced soil populations to below detectable levels. On the other hand, cover crops, including rye (two successive years) and rye/mustard (rye in the fall and mustard in the spring for two successive years) did not significantly reduce the soil population of V. dahliae. In the absence of fumigation, the most effective treatment was fallow, keeping the ground free of weeds for two years. Like *V. dahliae*, *Fusarium oxysporum*, cause of seedling disease in pines, tends to persist in soil and can be difficult to manage without soil fumigation. However, there are significant differences between strains in terms of pathogenicity and their ability to colonize non-susceptible crops. A better understanding of the strain specificity, or lack thereof, in the pathogen affecting pine seedlings, would help in identifying the most promising control strategies.

Sphaeropsis sapinea as a Nursery Pathogen: Experience with Red Pine in Wisconsin.

[1]Glen R. Stanosz, G. R., Blodgett, J. T., and Smith, D. R. [1]University of Wisconsin, Madison, WI

Shoot blight and canker caused by the fungus *Sphaeropsis sapinea* (syn. *Diplodia pinea*) is an important and worldwide disease of conifers, especially 2- and 3-needled pines. Some of the most frequent and severe damage caused by *S. sapinea* in North America has occurred in Wisconsin on red pine (*Pinus resinosa*) during the last 25 years. This conifer is the most economically important and frequently planted host in the state. Damage in nurseries includes reduced germination and seed rot, late damping-off, shoot blight, and collar rot. Without control measures, incidence of shoot blight among red pine seedlings in Wisconsin nurseries has exceeded 30 percent. Chronic occurrence of the disease on red pine nursery seedlings, therefore, has led to dependence on chemical application in each year of a 2- or 3-year production cycle to minimize losses and maintain production of healthy stock.

A nursery study was conducted to evaluate possible chemical alternatives to the fungicide benomyl for control of shoot blight caused by *S. sapinea* on red pine (1). Replicated plots of seedlings in their first or second growing seasons were treated either weekly or biweekly with one of the following materials (or combinations): benomyl; thiophanate-methyl; mancozeb; thiophanate-methyl + mancozeb; chlorothalonil; copper; myclobutanil; myclobutanil + thiophanate-methyl; water (control). Plots were located in three complete blocks at increasing distances from an inoculum source, diseased trees in a red pine windbreak. Percentages of seedlings affected by shoot blight were determined by examination in late fall. Analyses of variance indicated significant treatment and block effects ($p<0.001$) effects on disease incidence. The most effective materials applied either weekly or biweekly to seedlings of either age were the systemics benomyl and thiophanate-methyl, and the protectant chlorothalonil. In spite of fungicide application, incidence of disease was generally much higher in plots within the block closest to the red pine windbreak and lower in plots farther from this windbreak. Results confirmed the desirability of integrating chemical (protective sprays) and cultural (sanitation) practices for control of Sphaeropsis shoot blight in conifer nurseries.

Futher studies have confirmed the existence of two subgroups within *S. sapinea,* and demonstrated differences in the interactions of these groups with red and jack pines (2, 3, 4). Analyses of random amplified polymorphic DNA (RAPD) markers allow differentiation of two distinct groups (A and B) of the pathogen. Isolates of each group are capable of infecting seedlings without wounding. Frequency of symptom development by nonwounded seedlings varied both by pathogen group and by host species (97% for A isolates and 18% for B isolates on red pine; 42% for A isolates and 6% for B isolates on jack pine). Symptom severity also was evaluated on shoots of seedlings that were wounded and then inoculated with isolates of each group. On average (both species combined) inoculation with A isolates resulted in needle necrosis 7.0 cm from inoculation sites, compared with 1.4 cm for B isolates. Thus, A isolates, as a group, might be considered more aggressive than B group isolates, at least on these hosts. Consistent with this conclusion, the preponderance of isolates that we have collected from epidemic locations have been characterized as A group isolates.

Recent reevaluation of the relationship between red pine seedlings and *S. sapinea* included an investigation of the possibility that aggressive, A group strains of pathogen persist on or in asymptomatic nursery seedlings (5). One hundred asymptomatic red pine seedlings were collected in November 1994 in each of two nurseries, and 100 asymptomatic jack pine seedlings were collected at one of the nurseries. Each shoot was divided into four subsamples: five needle pairs from the current year's growth; five needle pairs from the previous year's growth; a stem segment from the current year's growth; a stem segment from the previous year's growth. Subsamples were surface-disinfested, placed into water agar slants, and incubated for approximately 3 mo. Identification of *S. sapinea* was based on examination of spores from pycnidia that formed on the plant tissue. The fungus was associated with 27.5% of the red pine nursery seedlings, but with none of the jack pine seedlings. With only one exception, the fungus was associated with stem segments of the previous year's growth. Isolates were confirmed as both virulent on red pine and aggressive (able to cause severe disease) by inoculation. The ability of these strains to persist on or in asymptomatic nursery seedlings may provide a means of dissemination and also may help explain pathogen survival and rapid disease development under conditions that induce host stress.

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WORKSHOP

Biological Control of Noxious Weeds

Moderators: Nancy J. Sturdevant and Sandra Kegley

The theme of the session was to focus on current work in biological control of weeds and future needs. Many folks from western regional Forest Health Protection presented results of projects they have been involved with over the past several years. We also had participation from eastern regions and from state agencies. We were impressed by the level of participation in a session covering such a new topic for the work conference. We have included several abstracts from the session.

Developing techniques to monitor insects as agents for biological control of spotted knapweed (*Centaurea maculosa*), and determining optimal site related release strategies.

Nancy J. Sturdevant and Sandra Kegley (R1)

During the 1997 field season, we sampled 67 sites to develop the monitoring tools and risk-rating system. At each site, 52 roots were collected and examined for larvae of both species. Adults were also surveyed at each site using a visual estimate technique. During each sampling period, weather parameters including temperature, wind, precipitation, and cloud cover were measured. Adult insect populations were only monitored between the hours of 11 am and 2 pm, and on clear days with little cloud cover. We also evaluated the impact of the root feeding insects on knapweed populations at 13 sites. At these sites, we will have both pre- and post-release vegetation density measurements and insect population measurements.

We also determined the presence of three knapweed seed head feeding insects, *Urophora affinis, U. quadrifasciata* and *Metzneria paucipunctella,* from several north Idaho locations, Faragut State Park and a Hayden location. This should enable land managers to have more accurate numbers of insects found in a bundle of knapweed stems from these sites for their releases. Parameters measured for the development of the risk rating system included: insect population measurements of both the adults and larvae, years since released, number of insects released, habitat type, elevation, slope, aspect, forest type-where applicable, stand topography, stand structure, disturbance factors, vegetation, land use, canopy cover, vegetation cover, annual precipitation, knapweed density, size of knapweed infestation, knapweed infestation type, soil type and soil nutrients.

During 1998, we sampled an additional 58 sites in both Montana and Idaho to further develop the monitoring tools and the risk-rating system. Many of the new sites were county releases. As many as 169 *Agapeta* larvae and 13 adults were found at one site. The larval sampling technique used in 1997, and the adult visual sampling techniques were evaluated at the additional sites in 1998. In 1998, we also evaluated several new monitoring techniques for the two root feeding insects including pheromone trapping for *Agapeta* and sweep netting for the adults of both insects. Data from the additional sites will strengthen our analysis of site characteristics and our evaluation of our monitoring techniques. We also continued to evaluate the impact of the two root feeding agents on knapweed at the selected 13 sites. The data from the impact study is currently being analyzed.

Where insects were found on sites at least one-year following the release, they are considered to be reproductively established. Forests and Counties were grateful to have the information on whether or not their releases of biological control agents were established. Many were also shown how to monitor the insects using several of the techniques that we were developing. However, whether or not the insect population is having an effect on the knapweed density at the 125 risk-rating sites was not determined from this study. Each site will have to be monitored using our monitoring techniques over time to make this determination.

Products that are in the final stages of development:

1. A monitoring system to determine establishment and spread of biological control agent introductions.
2. A risk-rating system of site characteristics to predict optimum sites for releases of biological control agents.
3. An evaluation of the impact of the both *Agapeta* and *Cyphocleonus* on spotted knapweed.

Evaluating the Use of Pheromones for Monitoring the Establishment of *Agapeta zoegana* (Lepidoptera: Tortricidae), a Biological Control Agent of Spotted Knapweed

Nancy J. Sturdevant (R1)

Very little work has been done on using pheromones to monitor beneficial insects such as *Agapeta zoegana* Haw., a biological control agent of spotted knapweed, *Centaurea maculosa* Lam. Spotted knapweed is a perennial aggressive weed that has invaded nearly three million hectares in nine western states and Canada, with over two million hectares invaded in Montana alone. Land managers have been releasing *A. zoegana* for spotted knapweed control over the past decade or more. However, at most of these sites, it is unknown if releases have become established, spread or are impacting the knapweed populations because of a lack of monitoring tools. The objective of our study was to evaluate the attractiveness of *A. zoegana* to four pheromone formulations at three field sites in Montana, and to evaluate pheromones as a monitoring tool for *A. zoegana* populations.

Three field locations were selected that had established populations of *A. zoegana*. Two sites were located on the Lolo NF; Valley of the Moons and Mormon Peak. The third site was located on the Flathead Indian Reservation, Garden Gulch.

The traps were checked at weekly intervals at each location. Number of *Agapeta* moths per trap were recorded. Following the last weekly inspection, the traps were collected and the total number of moths found was recorded.

A total of 396 moths were collected across all sites and all pheromone compounds. Only five moths were caught in the control traps. The highest number of moths were trapped at Mormon Peak. The results of this study show that there is great potential for using pheromones for monitoring the establishment of *A. zoegana* populations. Perhaps one of the greatest attributes of developing and using a pheromone based monitoring system is that very little training is required and sampling error should be very low.

This study has identified which of two pheromone compounds is more attractive to *A. zoegana* in Montana. The next step is to identify the strength of Z11-14Ac for monitoring objectives and to develop a prediction system that relates trap catches to actual population measurements and impact.

A report has been written and will be released in 1999. For more information on this project contact Nancy J. Sturdevant, (406) 329-3281.

Biological Control of Yellow Starthistle

Carol Bell-Randall (R1)

The forest health technology enterprise team (FHTET) has recently published "Biology and Biological Control of Yellow Starthistle. This document is the result of a Technology Development Project (TDP) geared to developing a template for transferring biological control of noxious weed information to the field, thus encouraging the use of biological control as part of an integrated weed management strategy. While working on developing appropriate technology transfer tools, the cooperators on the TDP conducted a number of field releases and distribution surveys to describe and increase the distribution of the 5 approved biological control agents for yellow starthistle. Examples of some of the information tables were shared with the workshop, and copies of the document were handed out for review. For copies of the document interested parties can contact Tom Barbouletos at the flathead national forest or Carol Bell-Randall at the Idaho Panhandle National Forest.

Pacific Southwest Region

John Wenz (R5)

The best currently available information indicates that the Pacific Southwest Region has about 58 noxious weeds that are impacting approximately 225,000+ acres of forest and rangelands in California. The impacted acres are very likely to increase as more complete, survey data becomes available. Noxious weeds are also significant pests in Hawaii (with over 1,000 established non-native plants) and other parts of Region 5 in the western Pacific. Primarily because of the economic significance of agriculture in California, the State has a very aggressive, loosely coordinated, noxious weed "program(s)" including biological control efforts. Agencies involved include the California Department of Food and Agriculture, the University of California (Berkeley, Davis, Riverside), the University of California Cooperative Extension Service and Farm Advisors, and the County Agricultural Commissioners. In addition to maintaining its own Noxious Weed Program, the Forest Service coordinates as appropriate with the other agencies and partners. Noxious weeds of importance in California include Yellow starthistle, *Centaurea solstitialis*, Klamath weed, *Hypericum perforatum,* Cheatgrass, *Bromus* *tectorum*, several thistles and knapweeds and in Hawaii, Koster's curse, *Clidemia hirta*, Fayatree, *Myrica faya*, Miconia, *Miconia calvescens*, and Christmasberry, *Schinus terebinthifolius*.

A Progress Report on the Effects of Interactions Between Biological Control Agents and Chemical or Fire Treatments for Managing Spotted Knapweed

Dennis Vander Meer, School of Forestry, University of Montana, Missoula, MT
Diana L. Six, School of Forestry, University of Montana, Missoula , MT
Nancy Sturdevant, USDA Forest Service, Region One, Missoula, MT

Spotted knapweed (*Centaurea maculosa*) is a nonnative invasive weed infesting large areas of public and private land in the western United States and Canada. It greatly reduces the forage and bio-diversity of the areas it invades. This project consists of two linked studies which are conducive to use as demonstration projects, displaying the effects of integrated approaches in spotted knapweed management.

The first study will evaluate the effects of herbicide applications (Tordon and Transline) on the survival of two root-feeding biological control agents, *Agapeta zoegana* and *Cyphocleonus achates*. Transline is being utilized because of its mild effects on mature trees and Tordon because of its widespread use in knapweed management. This study will also determine whether different densities of knapweed, achieved through varied application rates of the two herbicides, affect the ability of biological control agents to increase population size and efficacy. Experimental treatments are designed to determine which knapweed densities are optimal for the insects and which concentrations of herbicides will achieve these densities. The design is a randomized block design with seven treatments (three concentrations of each herbicide and one control) replicated three times at two sites. Pre-treatment monitoring was completed in the summer of 1999. Post-treatment monitoring will be done in the summer of 2000 and 2001 to determine changes in densities of both biological control insects and knapweed.

The second study will determine whether soil heating, as a result of fire, affects the survival of immature stages of *A. zoegana*. An LC-50 will be determined using drying ovens and thermocouples. Temperature gradients will also be determined in knapweed roots, in prescribed burn situations, using cans containing knapweed roots and thermocouples at varying depths.

Data from these studies will be helpful in developing forest weed management strategies over a wide range of situations. The utilization of Tordon and Transline will allow inferences concerning both rangeland and forested areas. In addition, the soil heating experiments will help answer questions concerning possible conflicts between biological control agents and prescribed burns.

WORKSHOP

Fifty Years of WFIWC, Fifty Years of Spruce Beetles
Historical Review of the WFIWC and White River Spruce Beetle Epidemic

Moderators: J.M. Schmid & R.D. Averill

Wickman Presentation

Wickman intended to present historical information on the WFIWC but could not attend because of prohibitive expenses associated with the 1999 meeting--room rates of about $100 per night, a registration fee of $75, plus cost of transportation was exorbitant for retirees.

1950 meeting in Fort Collins. 1st vs. 2nd WFIWC---a matter of debate. A 1949 meeting in Portland was first meeting of entomologists but was held in conjunction with the Western Forestry & Conservation Association meeting and was organizational in substance, i.e., laid the groundwork and formulated constitution for future meetings. Some consider this to be the 1st WFIWC. The first meeting of solely entomologists to discuss western forest entomological conditions, research, and control projects---now the essence of the WFIWC---was held December 15 & 16, 1950 in Fort Collins, Colorado. A meeting notice and minutes of that meeting indicate it to be the 1st.

1950 meeting was probably held in Fort Collins because of the work of the Forest Insect Laboratory in Fort Collins in conjunction with then current Spruce Beetle (SB) epidemic on the White River National Forest. A good portion of the meeting dealt with the SB epidemic. 28 people attended a meeting in the Armstrong Hotel---downtown Fort Collins, south edge of the older part of the city's business area. Most attendees dead now but two former CSU professors are still alive---C.W. Barney & E.W. Mogren. An interesting sidelight--a single room with bath at the Armstrong cost $2.75. Current room rates at the Village at Breckenridge are about 40X greater. If the Armstrong's rate were in effect today, Wickman would be attending this conference and making his presentation!

The 1999 meeting, approximately 50 years after the 1st WFIWC in Fort Collins, has an interesting similarity to the 1950 meeting---namely, primary concern for forest entomologists with SB problems. Colorado has current SB epidemics on several National Forests, and may be be faced with an epidemic rivaling the White River SB epidemic because of the 1997 blowdown on the Routt NF. R.D. Averill (Region 2) will discuss current SB activities in Colorado.

White River Spruce Beetle Epidemic

The White River SB epidemic ranked as the most destructive SB epidemic until recently when the SB epidemic in Alaska exceeded it in area of infestation and volume of timber killed. Chronologically, the White River epidemic developed as follows (compiled from the reports of McCambridge, Terrell and Wygant on file at the Rocky Mountain Forest & Range Experiment Station in Fort Collins):

1939. Hurricane winds (>75 mph) blew down extensive stands of Engelmann spruce on the White River Plateau on June 19, 1939 (Terrel's report, June 27, 1946). The winds lasted for 2 days and occurred on other National Forests-Routt and Grand Mesa-as well. The windthrown trees were heavily attacked by the SB and tremendous broods were produced.

June is typically a wet month in the high country of Colorado with soils wet by either precipitation or melting snow. Spruce, being shallow-rooted, is highly conducive to windthrow under these conditions.

The heavy attacks on the windthrown trees indicates a high SB population existed at the time of the windstorm, something more than endemic and probably an incipient epidemic. Terrell's April 16, 1947 report indicates the endemic level of SB populations in mature Engelmann spruce stands was thought to be 1 infested tree per 20 acres. Terrell's January 27, 1945 report indicated investigators as describing SB populations as being in a "heavy endemic stage" which probably meant that the populations were above the endemic level and tree mortality was greater than what would be expected at endemic levels. When blowdown occurred in 1939, the situation was ideal for a major epidemic. These conditions sharply contrast with the recent Routt blowdown where SB attacks on the blowdown appear light and the SB population(s) endemic.

During public meetings on the Routt Blowdown, questions were asked about the size of the blowdown from which the White River SB epidemic orginated. One rumor had the epidemic starting from an area less than 160 acres. Although Wygant does not state a specific size for the blowdown, his statement implies the area of the blowdown was considerably more than 160 acres. Terrell's April 16, 1947 report of the conditions in 1946 indicates windthrow occurred over thousands of acres. Considering the fact that the blowdown occurred on other National Forests as well, it seems highly improbable that the White River epidemic originated from an area <160 acres. Pictures in Terrel report and statements in 1944-47 reports show that the blowdown was similar to the recent Routt Blowdown in that the blowdown ranged from scattered trees to large patches of trees.

1941. Infested standing trees were discovered. This is consistent with the 2-year life cycle. Substantial numbers of SB-infested standing trees also suggests a high SB population.

1943. Infestatation continues to increase and SB attack trees regardless of size or vigor. Parts of the population are carried by strong winds to the Routt and Arapaho National Forests---those carried to the Routt traveled over 10-15 miles of nonhost type before reaching Engelmann spruce stands on the Routt.

1943-48. SB infestation continues to increase and spread during this period, killing the most of the mature spruce over extensive areas. By December 1944, more than 7,500,000 mature spruce killed. 99% mortality of overstory spruce was common, and by 1948, most of the merchantable spruce on the White River National Forest north of the Colorado River had been killed.
No control was recommended because (1) control methods were inadequate (no tested methods available), (2) knowledge of SB life history inadequate for control purposes, and (3) WWII caused wartime shortages of manpower, equipment, and materials.

1949. 3.5 billion bd. ft of spruce had been killed by 1949. Strong northwest winds carried SB southeasterly across the Colorado River to parts of the White River NF south of Eagle, Colorado and into relatively uninfested areas. Flight mortality was heavy as beetles passed over 25 to 30 miles of nonhost type (sagebrush, river, etc.) before encountering spruce stands south of Colorado River.

Magnitude of the SB population evident from two observations: Yeager's observation of a solid layer of beetles 6" deep and 6 ft or more in width along the east shore of Trappers Lake---east shore of Trappers Lake is >1.25 miles long, and workers at the airport between Gypsum and Eagle, Colorado observed hordes of SB in that vicinity in July, 1949.

1950. Control efforts begun. Treatment was accomplished by hand pump application of an orthodichlorobenzene-No.2 fuel oil solution to the boles of standing infested trees. Trees were sprayed to a height of 1.5 ft above the bark surface debarked by woodpeckers. Pumps capable of reaching 30-35 ft aboveground. Trees sprayed on 4 sides, drenching bark from top down. Treated trees ranged in diameter from 7" to 36". In one area, trees of only 2" were treated.

Insecticide mixed in Denver and then transported via tank trucks to central storage reservoirs in the treatment areas. I-70 did not exist at that time so transportation was probably over Loveland Pass and Vail Pass or via Berthoud Pass and Kremmling. Insecticide thence transported via jeeps, weapons carriers, and pack horses to treating crews on location. Insecticide carried in 5-gallon jeep cans (WWII gas cans) and applied from these cans with use of stirrup pumps. Packhorses carried 4 cans, i.e., 20 gallons. Treatment crews consisted of 7 men; chief spotter, 2 nozzleman, 2 pumpers, and 2 packers.

14 camps were established with the number of men at each camp ranging from 33 to 100.

1950 treatment statistics:

Trees treated	784,082
Acres treated	33,301
Insecticide applied	1,003,253 gallons, 1.28 gallons per tree
Cost	$1,773,155

1951. Temperatures recorded at -56 degrees at Eagle, and -49 degrees at Kremmling, Colorado on February 1, 1951. These temperatures contributed greatly to beetle mortality which ranged from 74% to 99% (average 87%) in the different infested areas during the winter 0f 1950-1951.

1951. Treatment Statistics:
199,002 trees treated
1.9 gallons per tree
Mess contract = $3.05 per man day
Horse contract = $4.75 per day (included feed and wrangler)

1950-1952. 1,200,000 trees treated.

A 16mm film was made of the chemical control effort against the spruce beetle epidemic on the White River National Forest. It features W.F. McCambridge and was shown so workshop attendees could see activities during the final years of the White River epidemic. Several members of the workshop requested copies of the film and work is currently progressing to duplicate the film on videotape.

Current spruce beetle conditions in Colorado were discussed. Averill noted that spruce beetle epidemics were present on different National Forests but Forest Pest Management was especially concerned with the possibility of a major epidemic developing around the extensive 1997 blowdown on the Routt National Forest. The blowdown ranged from individual scattered trees to extensive areas exceeding 2,000 acres. Total acreage of the blowdown was about 20,000 acres of which 12,000 acres lies within the Mt. Zirkel Wilderness area and 8,000 acres lies outside the Wilderness boundaries. Beetle attacks on windthrown trees have been found in a number of locations in the blowdown but populations are generally light. An incipient epidemic infestation near the south boundary of the blowdown may become a major problem if the beetles inhabit the blowdown and the population increases further. The Routt has undertaken a major public information program regarding the blowdown and has initiated a small number of timber sales dealing with the blowdown in accessible areas outside the Wilderness.

WORKSHOP

Spatial Analysis – How Can We Use It

Moderator: Jose Negron

In recent years, there has been a marked increase in the application of spatial analysis techniques to forest insect and disease studies. In this workshop, participants shared a short topic (about 5 minutes each) related to the utility of spatial analysis in forest insect and disease ecology. Afterwards, attendees and participants interacted and discussed various aspects of scenarios where spatial analysis techniques may be used. The following sections summarize some of the general comments made by the participants.

Geostatistical Analysis of Douglas-fir Beetle-caused Mortality

Jose F. Negron, Research Entomologist, Rocky Mountain Research Station,
Fort Collins, CO

In a recent study conducted by Jose Negron, John Anhold (Entomologist, Forest Health Protection, Ogden UT), and Steve Munson (Entomologist, Forest Health Protection, Ogden UT) we examined how the spatial distribution of Douglas-fir basal area influenced the spatial distribution of Douglas-fir beetle-caused mortality. We established two 4-hectare plots in the Wasatch National Forest in Utah. In each plot a Douglas-fir beetle outbreak had recently collapsed. In each plot we established at 10m X 10m grid and at each node measured Douglas-fir basal area before and after the Douglas-fir beetle outbreak. We then constructed omnidirectional variograms for Douglas-fir basal area before the outbreak and for residual Douglas-fir basal area after the outbreak. We examined variogram characteristics and concluded that:

- The Douglas-fir beetle-caused outbreak contributed to a more even distribution of basal area across the study areas by removing high density pockets of basal area within the stand. This was observed by reduced sill values obtained in the variograms of residual basal area and an increase in the spatial dependency explained by the fitted variogram models.
- The scale at which Douglas-fir beetle causes mortality in terms of the size of basal area clumps is less than 100 meters. This was observed in the ranges obtained in the variograms.

This illustrates one of many fashions in which spatial analysis can help us in addressing applied and basic ecological questions of forest entomology and pathology. We used it in this study to examine how an insect outbreak may change forest characteristics and determine the scale at with an organism operates.

A Statistical Structure for the Analysis of Spatial Data

Haiganoush K. Preisler, Pacific Southwest Research Station, USDA, Forest Service, P. O. Box 245, Berkeley, CA 94701. Email: hpreisler/psw@fs.fed.us

Here I will present two statistical methods for the analysis of spatially explicit data that are simple modifications of the standard linear regression model

Let *X(lat ,lon)* be the values of ***explanatory variables*** at a location with latitude and longitude coordinates *(lat, lon)*. Examples of such variables are habitat characteristics at a given location (e.g., elevation, soil type, slope, aspect, percent cover), distances between a location and other features of interest (e.g., distance to nearest road, distance to nearest infested tree), or stand level characteristics that are the same at each *(lat, lon)* within a stand but differ from stand to stand (e.g., types of trees within a stand, density of trees in a stand).

Let *y(lat, lon)* be the value of a ***response variable*** at location *(lat, lon)*. Examples of response variables are number of insects, number of infested trees, condition of a tree (dead or alive, infested or not), height of tree, age of tree.

Given a set of spatially explicit explanatory and response variables, scientists are often interested in ***questions*** such as: 1) Are there any discernable effects of the explanatory variables on the response of interest? 2) What are the relationships between various levels of the explanatory variables and the response (linear, quadratic, logarithmic)? 3) What are the predicted values of the response variable at unobserved locations?

These questions may be addressed using one of the models described below. In the first model (***spatially correlated model***) correlation between neighboring points is included through the variance-covariance matrix. In the second model (***generalized additive regression model***) observations are assumed independent and the spatial pattern not accounted for by the explanatory variables is included as a spatial trend in the mean. Advantages of the generalized additive model are that (1) it is an efficient method for analyzing binary data and count data in addition to Gaussian data, (2) it allows us to assess the significance of covariates without making assumptions about the shapes of the relationships between the response variable and the explanatories.

1. SPATIALLY CORRELATED MODEL

The statistical equation for the spatially correlated model is given by

$$Y = X\beta + \varepsilon,$$

where β ≠is a vector of unknown parameters and*0* ε *0*is a vector of random errors with expected value **0** and variance-covariance matrixΣ. The variance-covariance matrix is usually modeled as a function of the distance between observations. Additionally, it is often assumed that as distances between observations increase, the correlation between the corresponding errors decreases. The variance of the difference between errors at two different locations, var[ε(?°lat$_{i,}$ lon$_i$) - ε (lat$_j$, lon$_j$)], is called the ***variagram*** (Venables and Ripley, 1997).

The parameters in the variagram or in the variance covariance matrix, Σ, may be estimated using restricted maximum likelihood algorithms (REML). Given an estimate for Σ, the parameters in β may be estimated using generalized least squares methods (GLS), see Venable and Ripley (1997 p.472). **Proc Mixed in SAS** (1997) has an option for various spatial covariance structures and can be used to calculate estimates of the parameters and check the significance of the various covariates. The parameter estimates may then be used to predict values of response at unobserved locations with a range of explanatories that are within the range of those in the observed regions.

2. GENERALIZED ADDITIVE REGRESSION MODEL

Generalized additive models are defined by two functions. (1) A link function,

$$\eta(\mu_i) = \beta_o + g_1(x_{1i}) + g_2(x_{2i}) + \ldots + g_k(x_{ki}) + g_{k+1}(lat_i, lon_i),$$

that describes the relationship between the expected value of y given by μ; the values of covariates, $x_{1i} \ldots x_{ki}$ at location (lat_i, lon_i), and the location coordinates (lat_i, lon_i). Here η is a pre-assigned function, e.g., logarithmic, logistic, or identity functions, and $g_1, \ldots, g_{k+1}$ are unknown smooth functions that are estimated from the data. (2) A distribution function belonging to the one parameter exponential family, e.g., Gaussian, binomial, Poisson (Hastie 1992). In this model spatial location is viewed as an explanatory variable that stands as a replacement for other important but unobserved covariates (Preisler *et al.* 1997, Hobert *et al.* 1997).

Cressie (1993) suggests analyzing data collected on a grid by fitting a model with additive row and column effect. Higher order polynomial regression can also be used to fit a spatial surface (see trend surfaces in Venable and Ripley 1997 p. 470). A more general procedure is to use a smoothing function in an additive model as described above. One such smoothing technique is the locally weighted regression routine (***loess***). Locally weighted regression overcomes the difficulties with irregularly spaced observations that plague the trend surface method and some kernel smoother techniques. The generalized additive model **(GAM) in S-PLUS** (2000) may be used to simultaneously estimate the smooth functions of location and of the explanatory variables. Plots of the smooth functions against the various covariates are helpful in studying the relationships between the covariates and the response in the presence of a spatial trend. A plot of the estimated smooth surface is helpful in detecting spatial trends that might be due to unobserved spatially explicit covariates.

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Spatial analysis at different scales, two examples.

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Spatial analyses are powerful and useful techniques for addressing many questions on the spread and effects of forest insects and pathogens. Previous reviews of applications and procedures used in forest pest management are described in Liebhold and Barrett (1992) and Maffei (1992). Since 1992 the use of some sort of spatial analysis in forest entomology and pathology has become very common; this trend has been supported by access to specialized software for spatial analysis and to geographic information systems.

Recent and continuing work on spread of dwarf mistletoe and hazard from white pine blister rust illustrate how spatial analysis can be used at either the scale of the tree-group or of the landscape. Dwarf mistletoe spreads to neighboring trees by ballistic flight over a limited distance. In aggregate spread is influenced by the size and distribution of nearby trees (and crowns) and mistletoe plants. A strategy for modeling mistletoe spread is described by Robinson and Sutherland (1995). Fundamental to this modeling strategy are descriptions of host clumping and infection patchiness. Host clumping is represented by a truncated distribution (in the binomial family) dependent on the mean and variance of tree density. Infection patchiness describes the autocorrelation of a target tree to its neighbors with an exponential decay function. In contrast, white pine blister rust spreads to pines only through intermediate infection of *Ribes* leaves. A model for predicting the potential, relative effects of blister rust in the Southwest is presented by Geils and others (1999). Although blister rust infection on white pine is affected by microclimate and proximity to *Ribes*, information on these variables is not directly available for mapping hazard across the district. Elevation, plant association, and topographic position, however, may serve as reasonable surrogates. A simple "spatial analysis" in the form of a display of sites ranked by topographic position reveals that this variable provides little information in the particular application to the Sacramento district. That is, sites in the database are broadly defined and combine areas of ridges, slopes, and bottoms that are suspected of have different infection probabilities. A more complicated analysis using the underlying digital elevation model may be needed to define and identify topographic position.

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Spatial Modeling of the Mountain Pine Beetle Attack Process

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Spatial dynamics play a central role in the community dynamics of highly mobile insects. For example, dispersal is one of the most important, yet least understood, factors of bark beetle population biology. Past research with the mountain pine beetle (MPB) indicates that spatial dynamics play a crucial role (Preisler and Mitchell 1993; Mitchell and Preisler 1991, Safranyik et al. 1992). The MPB has long been considered a major pest of western forests. As an aggressive bark beetle (one that kills its host) eruptions of this species are impressive events. Outbreaks can be both intensive (up to 80% or greater mortality) and extensive (covering thousands of contiguous acres), resulting in serious economic consequences. It is also becoming recognized that disturbances, such as MPB outbreaks, may be central to maintaining the structure, function, and health of western forests. Interpretation of the mountain pine beetle in this dual role as a serious economic competitor and as a co-evolved component of the ecosystem presents an interesting challenge. One important method we are incorporating to help address this challenge is development and analysis of quantitative models. Aggregation on and dispersal from a host are of such over-riding importance to MPB ecology that including spatial dynamics in model representations is essential for ecological credibility. The spatial self-focusing and self-dissipating aspects of this species chemical ecology are integral components affecting population spatial dynamics.

Over the past 6 years we have been developing a reaction-diffusion partial differential equation (PDE) model of the spatial interaction between the mountain pine beetle and its host trees, including critical components of the species chemical ecology (Logan et al. 1998; Powell et al. 1996; Powell et al. 1998; Powell et al. 2000). We are working on both the large, landscape-level scale, and the smaller, stand-level scale. From these modeling endeavors, we have observed that even starting with a completely homogenous environment, the positive and negative feedback generated by attacking beetles soon results in a rich, spatially dependent chemical landscape that tends to modify future events.

The large-scale mountain pine beetle redistribution process, as described by the nonlinear reaction-diffusion PDE, has proven to be remarkably descriptive of published observations of the behavior of attacking MPB populations. We were able to parameterize the small-scale model using field collected data from an infested MPB stand in central Idaho (Bentz et al. 1996; Beisinger et al. 2000). Included in this is the important switching behavior of MPB from a focus tree to other nearby trees (Powell et al. 1998). Our field results indicate that verbenone does not appear to act as a 'shield' around attacked trees, and is therefore not solely responsible for the switch of beetle attacks to a new tree. We evaluated our model of switching with respect to changes in the value of several parameters: 1) vigor of the secondary tree, 2) distance between the focus and secondary tree, 3) strength of background emergence, and 4) the rate of pheromone loss through the canopy. All four factors play an important role in the successful colonization of hosts in an area. Results from the model indicate that control measures based on stand thinning are probably successful, at least in part, because of interference with the MPB chemical communication. In most cases the boundary within which switching is likely to be successful was relatively insensitive to host vigor. Conversely, the boundary's spatial location was very sensitive to chemical loss rate through the canopy, which is the parameter most strongly reflecting stand density in this model. Consequently, this work suggests that interference with chemical communication among beetles is a critical component of stand thinning.

Our modeling endeavors have provided a convincing tool for analyzing MPB movement within a stand and across a landscape. From this we have been able to test researchable hypothesis. We are moving in the direction of using our models to include the spatial component of MPB populations into risk assessment tools for this important forest insect.

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WORKSHOP

Forest Health Monitoring in Urban Areas

Moderator: Mary Ellen Dix

Purpose: This workshop discussed current urban monitoring efforts, the development of urban forest monitoring protocols by a inter-organizational team lead by Dan Twardus (USFS Northeast Area) and Dave Nowak (USFS Northeast Forest Research Station), and the need for invasive species detection and monitoring protocols for urban and wildland-urban interface forests.

Rationale: The Forest Service in cooperation with state, federal and municipal partners has attempted to move forward the science for conducting urban forest health monitoring for the following reasons:

- The 69 million acres of urban forests provide tremendous ecological, economic and social benefits to the 80 percent of the nation's population that live in urban areas.
- More than 95 percent of forestry professional responding to a Northeast Area Urban Forest Health Needs Survey felt that tree health monitoring was an important part of long-term tree care management strategies.
- Urban forests provide different challenges for inventory and monitoring than rural forests.

Nonforest Forest Inventory and Analysis (FIA) Sampling: During 1999, FIA and the Maryland Department of Natural Resources sampled forest in Maryland. In conjunction with the Baltimore Long-term Environmental Assessment, a pilot study on non-forest plots was conducted in four counties around Baltimore, Maryland. Crews modified plot designs and combined and adapted sampling protocols from FIA, Forest Health Monitoring and Urban Forest Effects Model (UFORE) Programs.

Maryland Roadside Tree Assessment: This 1999 pilot study evaluated roadside tree conditions in Baltimore, Baltimore City, Carroll, Howard, Prince George and Montgomery Counties. National Health Monitoring Program protocols for crowns and damage assessments were used in the assessment of roadside trees.

Urban Forest Volunteer-Based Inventory and Monitoring Workshop:
In February 1999, the Sacramento Tree Foundation, and Pacific Southwest Research Station hosted a workshop in California. Federal, state and local governments, non-government organizations and consultants from California and neighboring states identified stakeholder inventory and monitoring needs and developed objectives and initial protocols. Participants identified education and local environmental data needed for community planning as primary outcomes of urban inventory and monitoring programs involving citizen volunteers (school-based, NPO-municipal street tree, neighborhood - based, sustainable communities and rural/ unincorporated areas).

Urban Forest Health Monitoring Protocols: In 1998, an inter-organizational Forest Health Monitoring (FHM) Team was established to assess the need for expanding forest health monitoring into non-forested urban areas and to establish protocols for measuring variables on nontraditional plots. During the summer 1999, Dan Twardus (Northeast Area) and Dave Nowak (Northeastern Forest Research Station) held a workshop for federal, state, municipal and non-government scientists to determine how inventory and monitoring efforts should be conducted in urban forest ecosystems. The team identified common national variables and is examining available FIA, FHM, UFORE, state and local protocols adapting existing or developing new protocols. The data collected would be used to characterize national trends and could not be used to quantify state trends because sampling within a state is stratified by city size, the number sample cities within a size range is limited, and the number of plots are limited within selected cities. The team plans to send the protocols out for comment nationally and then presenting the revised protocols to NASF and FHM during their respective February 2000 meeting.

Invasive Species Monitoring: In the United States forests, about 200 nonnative insects and diseases are regarded as invasive. Over 20 of these are regarded as highly invasive and have or potentially will cause serious damage to the ecological integrity of urban and wildland-urban forests. Invasive species monitoring needs to be made a standard part of protocols to determine forest ecological integrity. This monitoring effort would use 10 key invasive species as indicators. Key components of a FHM invasive species monitoring program should include:

- Invasive species monitoring in the protocols of FHM and FIA.
- Addition of a monitoring system in the wildland-urban interface around major port cities.
- Integration of data from urban forests plots, wildland-urban interface plots, Forest Service Pest Surveys, APHIS detection and surveys on potential forest pests, and detection surveys for forest pest/diseases escaping from port areas into an invasive species database of FHM-Information Management. This data would be used for all reports and would be available on a web site.
- Addition of an analyst to FHM crews who can identify (or teach identification of) key invasive species, supervise methods development, perform quality control, perform invasive species data accumulation and analysis process, and produce or supervise the production of invasive species reports.

Conclusions: The sampling design and intensity of urban protocols was considered crucial to the establishing national trends. Participants strongly recommended that the team work closely with statisticians to identify and eliminate potential sampling design and intensity problems. The sampling design and intensity also limits its applicability at the local and state levels. Data from state and local survey may provide a more accurate picture. The lack of current or potential new funding makes the implementation of an urban forest monitoring program questionable. Preferentially funding urban monitoring could severely impact other programs. State organization, if provided outside funding, would be willing to implement an urban monitoring program.

WORKSHOP

Alpine Fir Decline

Subalpine Fir Infested With Balsam Woolly Adelgid In Idaho.

Ladd Livingston, Idaho Department of Lands

The balsam woolly adelgid was discovered infesting subalpine fir in Idaho in 1983. Since then, aerial and ground surveys have documented its spread in Idaho over an area of approximately 14,000 square miles (8,960,000 acres). Within this area, tree mortality has primarily occurred in low elevation sites where subalpine fir occurs, mainly in cool air drainage bottoms. More recently it has been found killing trees in high elevation stands. It now covers most of the central one-third of the state. Long-term observation plots have shown that host mortality can exceed 85% within eight years. Subalpine fir is a critical species in many high elevation areas. The effects of the balsam wooly adelgid on aesthetics, hydrology, and other ecological values can be very important. The adelgid is likely to continue its spread throughout subalpine fir forests of Idaho and neighboring states.

Subalpine fir Decline Evaluation and Assessment Surveys in Western Colorado

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Subalpine fir decline is the most widespread tree damage problem in Colorado. The decline is present throughout the western United States and Canada, and in Colorado, is concentrated in the northern half of the state. Although subalpine fir has little value as a timber species, because of the growing importance of recreation in Colorado, concern has been raised regarding the impacts of the decline in ski areas, campgrounds and viewsheds. While subalpine fir decline is poorly understood, it is thought that a combination of insects (the western balsam bark beetle, *Dryocoetes confusus*, among others) and diseases (*Armillaria* and other root diseases) plays a role in tree decline and mortality. In 1998, aerial surveys flown in Colorado found an estimated 480,481 trees affected by the decline (Averill, 1999). Because subalpine fir retains its dead needles longer than other conifer species, this total may reflect several years mortality. In any case, subalpine fir decline affects more trees and acreage than any other single tree mortality factor throughout much of the central and northern Rocky Mountains.

In western Colorado, reports of subalpine fir mortality first began to come into the Forest Health Management Gunnison Service Center in 1990. Initial reports were from the White River National Forest, concerning mortality around Glenwood Springs and at the Aspen Mountain Ski Area. At the time, Colorado was in the midst of a drought cycle that lasted from approximately 1988 to 1994. As mortality increased from 1992-93, we were asked to develop and conduct extensive surveys to identify the location, distribution and severity of the decline at Aspen Mountain and Crested Butte Mountain Resort (CBMR). Less detailed assessments were later done at Snowmass, Aspen Highlands and Tiehack/Buttermilk Ski Resorts, and at the Four-Mile/Divide Creek area west of Glenwood Springs. Following are details on the two extensive ski area surveys. Details are available in two biological evaluation reports (Angwin 1995a, 1995b).

The surveys at Aspen Mountain and CBMR consisted of two parts: an aerial survey to identify areas with dead and dying conifers, and a ground survey to investigate the causes of mortality. Management alternatives and recommendations were later developed for consideration by Forest Service and ski area land managers. Following initial ground reconnaissance, aerial photo missions were flown over the two ski areas. The photos ranged in scale from approximately 1:8,000 (over high elevation terrain) to 1:12,000 (over low elevation terrain). In order to enhance the visibility of dead and dying trees, color infrared film was used. Following receipt of the photos, stand locations and cover types were delineated within the ski area boundaries. Dead and dying coniferous trees (presumably affected by root disease and/or bark beetles) were then identified on the photos. Stands with dead and dying trees were then visited, and individual and groups dead and dying trees were located and inspected. Trees with yellowing, red or thinning crowns were checked for root disease were checked for root disease by excavating at least two roots and looking for signs of disease-causing fungi. Bark beetle activity was identified by looking for exit holes, pitch and frass on fading trees, while the bark beetle species was identified by gallery pattern or bark beetle morphology. Other insect and disease conditions were noted as observed.

At both ski areas, the Engelmann spruce/subalpine fir stands were dense, and had very little regeneration underneath. Little vegetation management had taken place since the establishment of the ski areas. Individual and group mortality was easily identified on the color infrared photos. At Aspen Mountain, subalpine fir mortality was identified in 33 stands. Western balsam bark beetle was found in 32 of these stands, while Armillaria root disease was identified in 20 stands. At CBMR, subalpine fir mortality was identified on photos in 34 stands. Of the 28 stands that were visited (6 were not visited due to access or weather problems), Armillaria root disease was identified in 16. Western balsam bark beetle was evident in almost all of the stands. At both ski areas, damage and mortality was confined to the subalpine fir. A variety of stand-specific management recommendations were given, including thinning, silviculturally favoring Engelmann spruce, Douglas-fir and aspen, removing individual and groups of root diseased trees, and removing root disease centers and installing a 30-50-foot fir-free buffer zone around infection centers. Institution of "dynamic leave strips", where a vertical section of trees is removed along one side of a stand while fencing and planting a section on the opposite side of the stand, was also suggested. All recommendations were aimed at systematically replacing the old, dense spruce/fir stands with younger, less dense insect and disease-tolerant stands that contain fewer subalpine firs.

As stated above, the dynamics of subalpine fir decline are poorly understood. However, one possible explanation for the rapid increase in subalpine fir decline in western Colorado is that drought conditions after 1988 triggered a buildup in Armillaria that was present at low levels. The drought also resulted in a buildup of western balsam bark beetle populations which caused increased mortality both within and outside of root disease centers. Thus, we have identified three "modes" of subalpine fir decline activity throughout the central Colorado Rocky Mountains. It appears that existing Armillaria root disease centers cause varying amounts of mortality, depending upon external factors, primarily climate. Endemic populations of western balsam bark beetles respond to an increasing number of susceptible hosts by attacking and killing root disease affected trees. Finally, expanded beetle populations spread to adjacent stands, overcoming host defences and killing otherwise healthy trees.

Efforts to gain a better understanding of the dynamics of subalpine fir decline were begun in 1997. A working group consisting of entomologists and pathologists from USDA Forest Service Regions 2 and 4 established a series of permanent plots throughout Colorado, Wyoming and Utah. These plots joined plots which were previously established in the San Juan mountains of southern Colorado and at CBMR as part of the Permanent Plot Technology Development Project. The pupose of these plots are to provide data on insect and disease spread and intensification for the validation and calibration of pest simulation models.

The new subalpine fir decline plots were established during the field seasons of 1997 and 1998. Analysis of stand condition data was begun in 1999 and continues. Stands to be sampled were selected on the basis of aerial survey and in many cases represent stands most intensely affected by subalpine fir decline. Preliminary analysis of stand plot data has revealed that several factors may be implicated in stands greatly affected by subalpine fir decline. In general, these stands are very dense with basal area rates ranging from 100 - 200 ft^2 per acre. These stands are also frequently quite old, with the ages of dominants and co-dominants in the range of 100+ years. This is an age which may approach the "physiological rotation age" of subalpine fir. Finally, although measures of dead biomass/fuel loading were not taken, numerous comments refer to large amounts of woody debris in the affected stands. Data analysis continues and re-measurement of the permanent plots is scheduled for the field season of 2002.

While information on disease spread will require additional plot remeasurements, one interesting observation was that Armillaria root disease was found in both live subalpine fir and Engelmann spruce on the plots in the San Juan mountains, but at all other plots further north, the root disease was restricted to subalpine fir, and occasional dead Engelmann spruce. This data supports scattered observations that Armillaria infects and causes mortality in both subalpine fir and Engelmann spruce in southern Colorado, but in central and northern Colorado, appears to be mostly confined to subalpine fir. Because all Armillaria found thus far in Colorado is belongs to the biological species *Armillaria ostoyae* (Yun, *et al.* 1996), this host specificity cannot be the result of pathogen differences at the biological species level. Additional work is needed to sort out the significance of these observations.

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WORKSHOP

Bark Beetle/Fungal Interactions

Moderator: Diana L. Six

Interactions of bark beetles with fungi vary greatly. They range from direct interactions with symbiotic fungal associates and entomopathogenic fungi, to more indirect interactions with fungi causing disease in host trees. These interactions can be very complex. The southern pine beetle, for example, interacts with a number of unrelated fungi, each of which has a different effect on beetle fitness. Further, phoretic mites also interact with both the beetle and its associated fungi.

The association among the southern pine beetle and its associated fungi is probably the best studied, although large gaps in our knowledge of this system still remain. Other bark beetle systems are much less well studied. In fact, for the majority of bark beetle species, our knowledge is limited to taxonomic descriptions. This is due, in great part, to a tendency to focus research efforts on the economically important species of bark beetles, i.e. aggressive species that kill trees. This narrow focus has resulted in a limited view of how such interactions function. Most bark beetles are not aggressive. Out of an estimated 477 species of bark beetles in North America, fewer than ten ever commonly kill trees. As bark beetle/fungal associations appear to be ubiquitous, I feel that focusing only on aggressive species has been a real barrier to building a complete and unbiased picture of these associations.

Indirect interactions between beetles and fungi are also of considerable interest. These include interactions between bark beetles and fungi causing disease in trees. Fungal pathogens can predispose trees to attack by bark beetles. This connection has been best studied with root diseases, but other fungi such as white pine blister rust and Commandra rust have also been observed to predispose trees to beetle attack. Beyond predisposition, little is known. A number of areas remain to be investigated. For example, are trees infected with pathogenic fungi higher or lower in nutrients than uninfected tissues? Do shifts in nutritional content of tree tissues caused by pathogenic fungi increase or decrease beetle reproduction/fitness?

Much remains to be learned in this fascinating area. This session was organized to present some of the new research being conducted on a wide range of bark beetle/fungal interactions.

Potential for Use of an Entomopathogenic Fungus, *Beauveria bassiana,* for Management of Bark Beetles

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Conidia of Mycotech's strain GHA of *Beauveria bassiana* were evaluated for activity against adults of three species of economically important bark beetles: the mountain pine beetle (*Dendroctonus ponderosae*), the Douglas-fir beetle (*D. pseudotsugae*), and the pine engraver (*Ips pini*). Mature adult beetles were exposed to *B. bassiana* by immersing them in liquid suspensions of various concentrations of conidia (controls were exposed to liquid without conidia). The beetles were then placed individually in Petri dishes containing a small block of bark/phloem and monitored for 7 days. Time to death after exposure with conidia was dose dependent, with the onset of mortality delayed at lower doses. Most beetles exposed to conidia died of infection 4-6 days post-exposure. Pathogenicity of *Beauveria bassiana* to *Dendroctonus* and *Ips* bark beetles varied by species. The *Dendroctonus* species were more susceptible than *Ips pini* to the fungus; however, all beetles exhibited high levels of mortality even at relatively low doses of conidia. Results of our bioassays indicate that *B. bassiana* strain GHA is a virulent pathogen of these beetles with considerable potential for use in bark beetle management programs. Present and future work includes the development of an autodissemination exposure station and evaluation of the ability of *Beauveria bassiana* strain GHA to spread within the larval habitat

Biology, Demography and Community Interactions of *Tarsonemus* (Acarina: Tarsonemidae) Mites Phoretic on *Dendroctonus frontalis* (Coleoptera: Scolytidae)

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Dendroctonus frontalis Zimmermann, the southern pine beetle, is associated with a diverse community of fungi and mites that are phoretic on the adult beetles. *Tarsonemus ips, T. krantzi* and *T. fusarii* (Acarina: Tarsonemidae) may interact within this community in ways that link the population dynamics of *D. frontalis*, the mites and three dominant species of fungi. We explored species associations by comparing the dietary suitability of different fungi for *Tarsonemus* spp. All three mite species fed and reproduced most successfully on the bluestain fungus, *Ophiostoma minus*, which is an antagonist of *D. frontalis* larvae. Mites had lower population growth rates when feeding upon *Ceratocystiopsis ranaculosus*, one of the mycangial fungi and could barely reproduce when feeding upon *Entomocorticium* sp. A, the mycangial fungus that is most suitable for *D. frontalis*. During the time from colonization of a tree by *D. frontalis* adults until departure from the tree of their progeny (ca. 40 d at 30°C), mite populations feeding upon *O. minus* can increase by factors of up to 209 (*T. fusarii*), 173 (*T. ips*), or 384 (*T. krantzi*). These high growth rates are allowed by rapid development (age of first reproduction = 8-9 d), high fecundity (ca. 1 egg/d), and high longevity (>28 d). Precocious mating increases the chance that females are mated prior to colonizing a new tree and arrhenotokous parthenogenesis permits reproduction by

unmated females. *Tarsonemus* mites may introduce negative feedback into *D. frontalis* population dynamics by generating indirect interactions between *D. frontalis* and *O. minus*.

Ophiostomoid Fungi Associated with Bark Beetle Species Colonizing White Spruce in the Great Lakes Region

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Microbial associates can greatly impact the population dynamics of bark beetles both positively and negatively, by facilitating digestion, competing for phloem resources, and interfering with tree defenses (Barras 1973, Paine et al. 1997). White spruce (*Piceae glauca,* Moech) is an important component in the Great Lakes Region, but it has not previously been surveyed for bark beetles and their associated microorganisms in this region. Our objective was to characterize the major bark beetle associated Ophiostomoid species. White spruce plantations in northern Minnesota, northern Wisconsin and northern Michigan were evaluated. Trees were felled at each of 10 research sites on two occasions during the 1998 flight season. Thirty trees were felled in early May and 25 trees were felled in early July. The trees were left on the forest floor for six weeks to allow colonization. Insects were reared from the trees and a microbial dilution plating technique was used to isolate Ophiostomiod fungi from emerging live bark beetles (Klepzig et al. 1991). Fungi were also isolated from colonized and uncolonized host tissue.

The felled trees were predominantly colonized by secondary bark beetle species: *Dryocetes affaber (12, 098), Polygraphus rufipennis (1,899), Ips pini (359), Crypturgus borealis (111), Dryocetes autographus (46).* Only one "aggressive" species was found, *Dendroctonus rufipennis (30).* The time of colonization varied among insect species. *Dryocetes affaber* heavily colonized trees felled in July and only sparsely colonized the trees felled in May (10,640 versus 1,458). *Polygraphus rufipennis* was found in greater abundance in the early than later set of trees (1630 versus 269). Overall, half the beetle species were found in greater abundance in the early set of trees and half in the July trees. Spatial preference within a tree also varied among beetle species. Sections were cut from three diferent heights of test trees after colonization: base, middle-bole, and basal crown. *Dryocetes affaber* equally colonized all three sections. All other species preferred the basal section of the tree.

The number of species and the frequencies of association of Ophiostomoid species isolated from bark beetles varied among insect species. A total of 323 beetles were processed for the presence of fungi. Of these, 120 beetles had fungi (Table 1.). Five out of the six Ophiostomoid species were isolated from both the beetle and the host tissue of the colonized trees. *Ophiostoma nigrocarpum* was the only species found in the colonized tissue, but not on the beetles. No Ophiostomoid fungi were found on uncolonized spruce trees that were left standing as controls (N=30). These data illustrate that the beetles are vectors of the Ophiostomoid fungi in Table 1, because no Ophiostomoid fungi were found in uncolonized tissue, but they were often both found in the colonized tissue and on the beetles.

The frequencies of the Ophiostomoid species isolated from bark beetles were: *Ophiostoma europhioides 66%, Leptographium abietinum 13%, O. bicolor 10%, O. ips 10%, O. picea 5%.* Among *Dryocetes affaber,* and *Polygraphus rufipennis,* there was a correlation between the tree section from which the beetle emerged and the section from which we collected the tissue sample. This correlation was not analyzed for the other species due to their low numbers. Each beetle species predominantly carried one Ophiostomoid species (Table 1.). Only 6 individual beetles carried multiple fungal species. However, multiple colonies of the predominant fungus were often isolated from individual insects. These data suggest a positive relationship between bark beetle species and their most frequent fungus. The direct effects of fungi on secondary bark beetles has not been studied.

Table 1. Ophiostomoid fungi Associated with bark beetle species that emerged from colonized white spruce in the Great Lakes Region.

Beetle Species	**#Beetles with Fungi**	**# Fungal Species**	**Most Frequent Fungus**
Dryocetes affaber	85/185	5	*Ophiostoma europhioides*
Dryocetes autographus	4/5	1	*O. europhioides*
Ips pini	7/8	3	*O. ips*
Polygraphus rufipennis	24/125	4	*Leptographium abietinum*

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Interactions Between White Pine Blister Rust and Mountain Pine Beetles in Southwest Oregon Sugar Pine

Donald J. Goheen, USDA Forest Service, Southwest Oregon Forest Insect and Disease Service Center, Central Point, OR.

Cronartium ribicola, cause of white pine blister rust, is an exotic pathogen. The fungus was introduced in western North America in 1910 on a single shipment of infected eastern white pine delivered to Vancouver, British Columbia from France. The pathogen spread rapidly in the western United States, reaching Southwest Oregon in 1926. A combination of numerous pine and *Ribes* hosts and often ideal environmental conditions contributed to this rapid spread. On sugar pine (*Pinus lambertiana*) and other five-needle pines, *C. ribicola* infection results in formation of resinous lesions that girdle host stems. Blister rust causes topkill and branch mortality of large pines and outright death of seedlings, saplings, and pole-sized trees.

Mountain pine beetles (*Dendroctonus ponderosae*) are native insects that attack a number of pine species, including sugar pines. Usually, healthy, vigorous pines are not successfully infested and killed. Rather, the beetles prefer or are most successful on stressed or weakened hosts. Surveys suggest that white pine blister rust affected trees are preferentially infested by mountain pine beetles in Southwest Oregon. About 60 percent of the sugar pines infested by mountain pine beetles in surveyed areas exhibited evidence of previous infection by *C. ribicola* while infection levels for trees not infested by beetles in the same stands averaged about 35 percent.

In addition to blister rust, overstocking and associated competition appear to be the factors that most commonly predispose sugar pine to mountain pine beetle attack in Southwest Oregon. Sugar pine are considered to be at high risk of attack by mountain pine beetles when surrounding basal areas exceed 150 ft^2/acre. Prior to European settlement, many stands in Southwest Oregon experienced frequent, low-intensity fires that regulated stocking, especially of fire-intolerant tree species. Today after 50 to 80 years of successful fire exclusion, most of these stands have developed heavy understories of true firs and Douglas-fir and now have average basal areas of 200 to 300 ft^2/acre making their mature sugar pine components very susceptible to beetle infestation.

Mature sugar pines are suffering extensive and accelerating mortality due to mountain pine beetle and white pine blister rust throughout Southwest Oregon. On many sites when these mature trees die, there is little likelihood that they will be replaced because young sugar pine are subject to such high levels of blister rust-caused mortality. The long term prognosis for sugar pine in Southwest Oregon looks poor unless current trends can be reversed through such management practices as thinning around mature sugar pines to reduce competition and planting sugar pine that are genetically resistant to *C. ribicola*.

Chemical Aspects of Root Rot-Ponderosa Pine-Bark Beetle Interactions

Pierluigi Bonello[1], William R. McNee[2], Thomas R. Gordon[1], Werner Heller[3], Andrew J. Storer[2], David L. Wood[2] and Heinrich Sandermann, Jr[3]. [1]Department of Plant Pathology, University of California, Davis, [2]Division of Insect Biology, University of California, Berkeley, and [3]Institut für Biochemische Pflanzenpathologie, GSF München, Germany

In a search for putative chemical cues used by phytophagous insects to locate suitable feeding and breeding substrate, attention must be paid to the physiological status of the host plant. With forest coniferous trees it has long been assumed, and repeatedly observed, that bark beetles preferentially infest stressed trees, particularly when they are affected by pathogens. However, little is known with regard to the underlying chemical relations between these different taxa that might explain this phenomenon. Here we describe some systemic chemical changes observed in ponderosa pine in response to infection by the root rot pathogen *Heterobasidion annosum* that might influence bark beetle behavior. In particular, we report a systemic increase in the concentration of the soluble phenolic derivative ferulic acid glucoside in the phloem of infected trees, as well as an apparent concurrent decrease in the amount of lignin in the phloem of the same trees. These changes are discussed with respect to possible effects on bark beetle behavior.

The Potential For Pitch Canker Spread Through Infected Branches and Chips

William R. McNee[1], David L. Wood[1], Andrew J. Storer[1], and Thomas R. Gordon[2]
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[2]Department of Plant Pathology, University of California, Davis

In a two-year study of pitch canker (*Fusarium circinatum*)-infected Monterey pine (*Pinus radiata*), less than 2% of symptomatic branches with green foliage had twig beetles, *Pityophthorus* spp., emerge during rearing, while approximately half of branches with yellow and red foliage had twig beetle emergence. At two study sites (Pebble Beach and Oakland, California), the mean number of *Pityophthorus* spp. emerging from branches with yellow foliage (PB: 6.9 ± 1.0 [SE], Oak: 17.4 ± 2.5) was greater than the mean number emerging from branches with red foliage (PB: 4.9 ± 1.0, Oak: 11.6 ± 1.4). Overall fungal phoresy rates of emerging twig beetles were significantly higher at Pebble Beach (17.7 ± 0.6%) than at Oakland (5.3 ± 0.2%). Under laboratory conditions nearly all insects emerged within three months of collection. At both sites, there was significant seasonal variation in the proportion of branches colonized by twig beetles, in the mean number of emerging twig beetles, and in the phoresy rates of emerging insects. Chipping of branches reduced the emergence of *Pityophthorus* spp. and associates by approximately 95%, compared to intact branches. The pathogen was frequently isolated from 1 year-old branches and chips, but was recovered from 3 year-old branches in only one of 46 sampled. Since phoretic insects can emerge from recently-cut branches and chips, it is recommended that symptomatic branches and chips not be moved to areas where the disease is absent.

WORKSHOP

Database and Modeling Technology Development

Moderator: Judy Adams

Validation of the Western Spruce Budworm Model

Nancy Sturdevant Northern Region and Michael A. Marsden INTECS
(This information was also presented in a poster at the meeting)

Western Spruce Budworm Permanent Plots were established in 35 stands in the Northern Region beginning in 1992. Plot location extend from the Clearwater NF in Northern Idaho to the Lewis and Clark NF in Eastern Montana.
This includes several areas of Budworm outbreak in the late 1980s. Douglas-fir is the primary host species in each outbreak area except for the Nez Perce NF where both grand fir and Douglas-fir are primary hosts. Plot elevations range from 2500 feet above sea-level on the Clearwater NF to 7400 on the Deerlodge NF. Data taken from 1992 to 1998 includes the ending of Budworm outbreaks in all of the thirty-five plots. There is new defoliation recorded in the fall of 1999 in some plots. Plots were selected in three levels (low, moderate and high) of Budworm defoliation in the last 25 year. In addition in 4 areas, unthinned-plots were located adjacent to thinned plot.

A three step Analysis is planned for this permanent plot data: First) a statistical analysis of the data to define the effects of the last Budworm outbreak and test for differences by areas, forests, and thinning, Second) an evaluation of the Damage Model for the Western Spruce Budworm, and Third), an evaluation of the Bud-Lite Model. When the Permanent Pest Impact Plots were established one of the stated objectives was to validate the Pest Models. This will be done to the extent that the data allows. Validation of the Pest Models will require the analysis of other data from other forest locations in the west and future data from the plots in the Northern Region.

To work through the data management problems we have selected the permanent plots on the Beaverhead NF. These plots have a stand inventory in 1992, a second inventory in 1997, and pest damage inventories for each year since 1992. The pest damage inventories was recorded by the tagged trees from the stand inventory in 1992. Since the larger trees are selected as a prim-sample their attributes including pest damage must be weighted by the number of trees per acre represented by each sample tree. The trees must also be sorted into the three model-tree sizes for comparisons in the evaluation of the Budworm Damage-Model and the Bud-Lite Model output.

Since the basic design of the study is one of sampling the analysis will be done as a Nested-Analysis of Variance. Forests are nested within areas which experienced Budworm Outbreaks, Stands are nested within Forests, Sample points are nested within Stands and trees are nested within sample points. Contrasts for such management actions like thinning vs no-thinning can still be tested. The sample trees are the basic unit of observation.

The statistical analysis of the data from the Beaverhead NF has begun and will be completed shortly. This will be followed by the statistical analysis of all thirty-five plots. The evaluation of the models must wait until this winter when the Bud-Lite Model is linked and tested with the FVS variants approbate for the Northern Region.

Comments and Suggestion from others who are validation pest models.

Ann Lynch was concern that data taken by more than one observer must be carefully checked. She also pointed out that data taken on prism-plot trees 6-7 years after a budworm outbreak ends must be re-weighted to account for changes in diameter i.e. changes in trees per acre the trees represent.

John Muir asked when the Bud-Lite Model would be available for use with their PC version of FVS. In Western Canada they now have several years of data for checking or calibration such a model.

Ann Lynch cautioned that the Bud-lite Model is sensitive to the weather data. If complete weather data is not available great care must be taken in either estimating missing values for historic data or creating new sequences of weather data to simulate future conditions.

John Muir asked how others might join in this model validation process. In the discussion that followed both informal contact among interested parties and a formal Technology Development Project considered. The Northern Region will continue with its' efforts this winter and keep John Muir, Forest Service Research and the other western Forest Service Regions informed of the progress.

Application of Multiple Imputation in Forest Pest Survey Data Analysis

Shaoang Zhang, INTECS International, Inc. Fort Collins, Colorado and
Judy A. Adams, USDA Forest Service, Forest Health Technology Enterprise Team,
Fort Collins, Colorado

INTRODUCTION

Multivariate data are vulnerable to missing values. Forest health surveys, which measure usually dozens of variables to identify forest health status, frequently involve some missing data. Such missing data raise difficulties for subsequent data analyses and modeling. Traditionally, a procedure called case deletion is used to discard all incomplete observations and generate a complete data set. However, case-deletion procedure may be inefficient when it is used for a multivariate dataset in which the proportion of incomplete observations can be unacceptably high. For this reason, other alternatives are needed for missing value assignments while analyzing forest health survey data with missing values. Of these alternatives, multiple imputation (MI) that accounts for the uncertainty of missing value prediction by imputing more than once for each missing value is promising.

Since MI was proposed (Rubin 1977), substantial progress on MI has been made in the past two decades (Dempster et al. 1977, Rubin 1977, 1987, Little and Rubin 1987, Meng and Rubin 1993, Schafer 1997). The emergence of general software for MI in the past several years (Schafer 1997, Schafer and Olsen 1998, Prevention Science & Methodology Group, 1996) makes it possible for non-experts to apply MI in their applied fields. However, the application of MI in the analyses of forest data with missing values has not yet been adequately explored. This study is aimed at demonstrating the application of MI in forest health survey data analysis.

METHODOLOGY

Single imputation procedures such as conditional mean imputation impute each missing value only so that the uncertainty of missing value prediction is ignored. However, MI draws m ($m > 1$) times for each missing value from its posterior-predictive distribution to generate m complete data sets, which represent the uncertainty of missing value prediction. As shown in Rubin (1987), for most missing data cases, only 3-10 imputations are needed. For this reason, MI requires more work as compared to single imputation.

Most forest health surveys involve both continuous and categorical data. In other words, forest health survey data are "mixed" data. MI specified for incomplete mixed data is different from those for categorical or continuous data. The procedure is briefly described as follows.

The authors thanks Kelley Ronald with Vermont Department of Forest and Recreation for providing the data used in this study and Mark Riffle with INTECS International, Inc. for editing assistance.

Complete Data Model

Suppose mixed data $W = (X,Y)_{n \bullet (p+q)}$, where $X = (X_1, X_2, \ldots, X_p)$ represents categorical variables and $Y = (Y_1, Y_2, \ldots, Y_q)$ represents continuous variables. Categorical variable X_j takes possible values $1, 2, \ldots, d_j$ so that each unit (observation) in the dataset can be classified into one of the D ($D = \prod_{j=1}^{p} d_j$) cells. $x = (x_1, x_2, \ldots, x_p)$ denotes a possible realization of X.

Let $z = \{z_d : d = 1,2,\ldots,D\}$ be the full set of frequency of sample units that fall into cell d. Let U be a $n \cdot D$ matrix with rows $u_i', i = 1,2,\ldots,n$, where u_i is a D-vector with value 1 in position d if unit i falls into cell d, and 0 in all other positions. That is

$$U'U = diag(z) \qquad (1)$$

Therefore, z can be characterized by $U'U$.

With these notations, we can get the marginal distribution of X and the conditional distribution of Y given X. They are:

$$z|\pi \sim M(n,\pi) \tag{2}$$

and

$$y_i \mid u_i \sim N(\mu_d, V) \quad \text{for } i = 1,2,\ldots,n, \tag{3}$$

where M represents a multinomial distribution with parameters $\pi = \{\pi_d : d = 1,2,\ldots,D\}$, an array of cell probability associated with z, μ_d is a mean vector of continuous variables corresponding to cell d and V is a $q * q$ covariance matrix. It is assumed that V keeps unchanged across all cells.

Therefore, the parameters of general mixed data model will be

$$\theta = (\pi, \mu, V)$$

where $\mu = (\mu_1, \mu_2, \ldots, \mu_D)$.

Combining (2) and (3), we have the likelihood for θ:

$$L(\theta|W) \propto L(\pi|X)L(\mu, V|X,Y) \tag{4}$$

Since $L(\pi|X)$ is only associated with parameters π and $L(\mu,V|X,Y)$ is only associated with parameters (μ, V), maximum likelihood estimates of θ based on complete-data can be achieved by maximizing $L(\pi|X)$ and $L(\mu,V|X,Y)$.

Inference for parameters θ

Based on the partition in (4) and the application of independent distributions to π and (μ, V), if the prior distribution of π has a Dirichlet distribution with parameters α, denoted by $D(\alpha)$, the posterior distribution of π will be

$$\pi \sim D(\alpha') \tag{5}$$

where $\alpha' = \alpha + z$.

If we assume non-informative prior for (μ, V), the posteriors for (μ, V) will be

$$\begin{aligned} \mu_d|V,Y &\sim N(\hat{\mu}_d, z_d^{-1}V) \\ V|Y &\sim W^{-1}(n-D, ([illegible])^{-1}) \end{aligned} \tag{6}$$

where [illegible] is the estimation for the residual of $(Y - U\mu)$.
$\hat{\mu}$ is the estimation of μ. Obviously, it is required that $n \geq D + q$.

Predictive Distribution of Missing Values

When an arbitrary subset variables of X and Y are missing, the predictive distribution of missing values needs to take any additional information of X_{obs} and Y_{obs} into consideration. Let's index each cell in z by its corresponding response pattern of categorical variables, x, rather than its cell position d $(d = 1,2,\ldots,D)$. Thus, z_x is an element of an array with dimension $d_1 \times d_2 \times \cdots \times d_p$. Without losing any generality, we use $O_i(x)$ and $M_i(x)$ to denote the sub-vector of x corresponding to the observed and missing parts of the categorical data in unit i, respectively. The predictive probability that unit i falls into cell x given $O_i(x)$ will be

$$P(u_i = E_x \mid y_{i(obs)}, x_{i(obs)}, \theta) = \exp(\delta^*_{x,i}) / \sum_{M_i(x)} \exp(\delta^*_{x,i}) \qquad (7)$$

over the cells x for which $O_i(x)$ agrees with $x_{i(obs)}$, and 0 for all other cells. In (7),

$$\delta^*_{x,i} = \mu^*_{x,i}{}' V_i{}^{*-1}\, y_{i(obs)} - \frac{1}{2}\mu^*_{x,i}{}' V_i{}^{*-1}\, \mu^*_{x,i} + \log \pi_x . \qquad (8)$$

and E_x is a D array with 1 in cell x and 0 elsewhere. The conditional predictive distribution of $y_{i(mis)}$ is a multivariate normal with mean vector $\mu^*_{x,i}$ and covariance matrix $V_i{}^*$, where $\mu^*_{x,i}$ is a sub-vector of μ_x and V_i^* is a sub-covariance matrix of V, respectively, corresponding to the observed part of y_i.

Algorithm

Expectation-Maximization (EM) algorithm (see Little and Rubin 1987) is used to estimate parameters θ and impute missing values after convergence of θ estimation is achieved. The software developed by Schafer (1997) for mixed missing data is used to implement this algorithm in the study.

DATA

Selected data from Vermont hardwood forest health permanent plots were used in this study. This permanent plot system was established in 1985, and is composed of nearly 400 plots in 80 different hardwood forests across Vermont. All plots had been surveyed three times: in 1986, 1991, and 1996. Besides these three surveys, some of the plots were surveyed in 1998 after a severe ice storm hit Vermont during the winter of 1997. Only data from 1996 and 1998 surveys for those plots that were measured in both times were chosen for this study. As a well-designed forest health survey plot system, variables measured in these plots are typical of a forest health survey. Six variables--species, growth vigor, DBH, crown dieback, crown transparency and crown damage from the ice storm--were selected to demonstrate the application of multiple imputation. Of these variables, crown damage (six classes), species type (2 classes), and growth vigor (four classes) are categorical variables, while all others are continuous variables. In total, 322 complete records were available. To generate a missing dataset, around 20 percent of the records, each for crown damage, tree vigor, DBH, crown dieback, and crown transparancy, were randomly omitted. In doing so, more than 65% of the observations (211 observations) became incomplete, each of which included one or more missing values (Table 1). Inferences based on MI were compared to the complete data set and to the inferences from the case deletion procedure to show the appropriateness of MI for filling in missing values in a forest health survey dataset.

RESULTS

Using the software by Schafer (1997), three imputations for the generated missing data were conducted so that three complete datasets were produced through the imputation. The frequency table by categorical variables from the complete data set (before omitting observations), MI, and case deletion are summarized in Tables 2 and 3. The summary statistics for the three continuous variables are shown in Table 4.

By comparing the estimates of frequency tables for categorical variables and the summary statistics for continuous variables from MI and from case-deletion procedure to corresponding estimates from the complete data, the appropriateness of MI is evaluated. Tables 2, 3 and 4 suggest that the estimates from MI are very close to those from the complete data, while the estimates from case deletion are farther from those estimates based on the complete data. For instance, the maximum difference of cell frequency estimates between MI and the complete data is 2.3, while the maximum difference between case-deletion procedure and the complete data reaches 12.2. In Tables 3 and 4, the number of cells whose frequencies are not estimable by case deletion is 8 out of total 36 cells; in contrast, MI can estimate frequencies for all cells.

Table 1. Missingness pattern for example dataset 1

Variables						
Crown Damage	Species	Vigor	DBH	Dieback	Transparency	Frequency
1	1	1	1	1	1	111
0	1	1	1	1	1	29
1	1	0	1	1	1	22
0	1	0	1	1	1	1
1	1	1	0	1	1	28
0	1	1	0	1	1	5
1	1	0	0	1	1	5
0	1	0	0	1	1	2
1	1	1	1	0	1	23
0	1	1	1	0	1	6
1	1	0	1	0	1	9
0	1	0	1	0	1	3
1	1	1	0	0	1	4
0	1	1	0	0	1	2
1	1	0	0	0	1	1
1	1	1	1	1	0	31
0	1	1	1	1	0	3
1	1	0	1	1	0	9
1	1	1	0	1	0	5
1	1	0	0	1	0	5
0	1	0	0	1	0	1
1	1	1	1	0	0	5
0	1	1	1	0	0	2
1	1	0	1	0	0	6
0	1	0	1	0	0	1
1	1	1	0	0	0	2
1	0	1	0	0	0	1

Note: 0 and 1 denote missing and observed items, respectively

Table 2. Number of observations estimated for collapsed cells by vigor and crown damage

	Vigor											
	1			2			3			4		
Crown Damage	OC	MI	CD	OC	MI	CD	OC	MI	CD	OC	MI	CD
0	76	76.6	87.1	15	13.5	14.5	5	5.5	5.8	7	7.9	5.8
1	50	52.3	49.3	23	24.7	29.0	12	11.7	11.6	3	1.7	0
2	34	34.6	40.6	4	3.2	0	7	7.8	2.9	4	4.4	0
3	25	25.0	37.7	7	6.3	5.8	4	2.3	2.9	1	1.0	2.9
4	19	18.4	11.6	5	6.2	2.9	1	0.8	0	2	1.8	0
5	15	13.5	8.7	1	1.2	2.9	1	0.8	0	1	0.8	0

Note: OC – estimates from original complete data, MI—estimates from MI, CD—estimates from case deletion

Table 3. Number of observations estimated for collapsed cells by species and crown damage

	Species					
	Hardwood			Conifer		
Crown Damage	OC	MI	CD	OC	MI	CD
0	67	67.6	75.4	36	35.8	37.7
1	80	83.8	81.3	7	6.5	8.7
2	45	44.9	43.5	5	5.1	0
3	34	32.1	46.4	4	2.5	2.9
4	24	23.9	14.5	3	3.4	0
5	16	14.8	11.6	1	1.6	0

Table 4. Summary statistics for continuous variable from different procedures

	Mean			Standard Deviation		
Variables	OC	MI	CD	OC	MI	CD
DBH	10.06	10.19	9.75	4.9487	5.1194	5.1019
Crown Dieback	9.32	8.12	7.48	12.2236	8.8076	8.2732
Crown Transparency	18.25	17.89	17.79	6.4931	6.3951	6.2042

This study demonstrates that MI is an efficient missing data imputation procedure for filling missing values in forest health survey data even when the proportion of incomplete observations is high (more than 65% in the example dataset), and overall it performs much better than the case deletion procedure. A comparison between MI and some other imputation procedures that have been used in forest data analysis will be conducted in the near future to further evaluate the appropriateness of MI in forest health data analyses.

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WORKSHOP

Mountain Pine Beetle – The Next Wave?

Moderator: Joel D. McMillin, USDA Forest Service, Rapid City, SD

Presenters: Ken Gibson (USDA Forest Service, Missoula, MT), John Schmid (Fort Collins, CO), Tom Eager (USDA Forest Service, Gunnison, CO), Bill Riel & Terry Shore (Canadian Forest Service, Victoria, BC), Carol Bell Randall (USDA Forest Service, Coeud' Alene, ID), and Jesse Logan (USDA Forest Service, Logan, UT)

Participants: Approximately 25

McMillin introduced the session:

Mountain pine beetle (MPB) populations are on the rise again throughout many forests of the western United States and Canada. In particular, areas of Colorado, South Dakota, Wyoming, Montana, Idaho, and British Columbia have seen large increases of lodgepole and ponderosa pine mortality. For example, there has been a doubling of MPB-caused mortality to ponderosa pine in each of the last four years in the Black Hills of South Dakota.

This session was organized to discuss current management tools and strategies being implemented to combat this destructive beetle. Ken Gibson began by providing an overview of MPB and management actions in the Northern Region of the Rocky Mountains. John Schmid next discussed his ongoing research that is examining the role silviculture plays in ponderosa pine stand susceptibility to MPB attack. Tom Eager followed this presentation by sharing the results of a study that tested the use of plastic tarping to treat infested trees. The session concluded by Bill Riel and Carol Bell Randall discussing their work on developing prediction models and hazard rating systems, respectively. A lively discussion followed each presentation; so much so, that we were unable to hear Jesse Logan present research work on manipulating MPB populations in a push/pull strategy for improved fuelwood harvest management. There was agreement among the participants for a follow up session at a future WFIWC.

Past, Present, and Future Management of MPB in the Northern Region

Ken Gibson, FHP, Missoula, MT

The mountain pine beetle, *Dendroctonus ponderosae* Hopkins, is by far the most destructive insect pest of pine species in western North America. Although most pine species within its range will serve as host, lodgepole pine is its preferred--and most devastated--host species. Populations of the beetle have existed in an "outbreak" condition in much of the lodgepole pine type from northern Utah to British Columbia for most of the past 30 years. As a result, MPB has had a significant effect upon management philosophy, decisions, and activities throughout that period of time.

In the Northern Region, MPB epidemics have been reported with some regularity since early in the 20th century. The current series of outbreaks began concurrently in large expanses of unmanaged lodgepole pine in western Montana. In the mid-1960's, an infestation developed in Yellowstone National Park (NP). Within a few years, major outbreaks had developed on the Gallatin and Beaverhead National Forests (NF) to the north and west. In the early 1970's, MPB epidemics were first observed within Glacier NP. Within a few years, additional ones were noted on the Flathead, Kootenai and Lolo NFs and adjacent lands of other ownerships (Gibson and Oakes 1989).

By 1978, major MPB outbreaks existed on the Beaverhead, Gallatin, Flathead, Lewis & Clark, Lolo, and Kootenai NFs, in Yellowstone and Glacier NPs, on several Indian Reservations in Montana, and on much intermingled State and private land. In total, nearly 820,000 acres were infested. Extensive ground surveys in 1979 showed an estimated 33.4 million trees had been killed, to that date, on slightly less than 986,000 acres (Bennett, et al., 1980). Total infested area continued to increase until 1981. At peak outbreak level, almost 2.5 million acres were infested. Beginning in 1981, there was a gradual, but steady decline in area infested. By 1991, an estimated 163,300 acres contained trees killed by MPB during 1990 (Oakes and Gibson 1992). Declining to a low of 22,000 acres in 1994; beetle-infested acres are once again on the increase in western Montana and northern Idaho--infesting lodgepole pine stands regenerated after widespread fires in 1910. In 1998, more than 114,000 acres, mostly lodgepole pine, were infested by MPB, Region-wide. Aerial survey estimates for 1999 have not been compiled, but the infested area has continued to increase on parts of the Lolo and Idaho Panhandle NFs (Unpublished office report).

A combination of aerial survey and ground-collected data suggest more than 3 million acres, in the Northern Region, have been infested during the past 30 years. A conservative estimate indicates an average 80 trees per acre have been killed. Of those nearly quarter-billion trees, in excess of 90 percent were lodgepole pine (Unpublished office reports).

Until approximately the mid-1970's, pest managers somewhat naively believed that MPB-killed trees were the manifestation of a pest problem--and that the solution to the problem was simply one of removing the pest. Attempts at that solution were many and varied--ranging from cutting, piling and burning of infested trees to wide-scale applications of pesticides. Virtually all were unsuccessful (Klein 1978).

Finally, during the mid- to latter-1970's, we realized that the problem was not a plethora of beetles, but a preponderance of susceptible host type. We noted that lodgepole pine stands in which beetle-caused mortality was the greatest shared similar characteristics. Nearly all were older, densely stocked with large-diameter trees and growing at a combination of elevation and latitude conducive to optimal beetle development. Further, the most devastated stands were those on the best sites--having grown sufficiently well to develop thick phloem, prior to their slowing in growth and becoming susceptible to beetle attack. Recognizing these commonalities was a significant step towards the development of a more feasible means of reducing tree losses to MPB (Amman 1972).

One of the first major accomplishments was the advent of a "hazard-rating" system for unmanaged lodgepole pine stands. Developed by Gene Amman, and others, in 1977; it was used until very recently (Amman, et al., 1977). That system enabled us to identify those stands most likely to support MPB outbreaks as: stands in which the average diameter is greater than 8 inches; age exceeds 80 years; and which are growing at lower elevations and more southerly latitudes. Unfortunately, that recognition also led to the realization that--as a result of effective fire control over the past several decades and the "unmanaged" condition of most lodgepole pine stands--there were literally tens of millions of acres of susceptible stands in the western United States and Canada. We knew that lodgepole pine mortality caused by MPB would be significant--and that because the beetles could move through stands more rapidly than we could--even our best efforts wouldn't do much to "stem the tide."

Still, a knowledge of which stands were exposed to the greatest risk enabled us to concentrate efforts in the areas of highest priority. Our first "silvicultural" recommendations were identification and removal of high-hazard stands. Removing a stand prior to its being infested, accomplished at least two worthwhile objectives: realizing a better return on investments by selling timber at a "green" rate rather than a "dead" one; and more importantly, reducing the food supply of the beetle. The latter would have been more effective had we moved more rapidly than we did; but undoubtedly there was a net benefit in some local areas.

Though our ability to remove high-hazard stands was limited, the combination of stands regenerated and those killed by the beetle--which were salvaged as often as could be practicably done--resulted in overcutting in some areas. In a number of seriously affected drainages, other resource values were being threatened. That provided the impetus for exploring other silvicultural opportunities. Some of the first researched were "diameter-limit" cuts, in which the largest trees in the stand were removed. Those treatments often left stands of questionable quality, and were subsequently replaced by "basal area reduction" cuts. Impressive results were obtained with initial treatments. In several replicated studies, uncut "control" stands experienced beetle-caused mortality exceeding 90 percent of the trees over 5 inches in diameter. Nearby treated stands, subjected to similar MPB pressure, showed average mortality rates of 38 percent for the 120 BA cuts, and less than 10 percent for the 100 and 80 BA thinnings (McGregor, et al., 1987).

Those studies, provided a broader range of alternatives for MPB-threatened lodgepole pine stands. They ultimately led to the development of guidelines for selecting stands in which such treatments might be most successful. These guidelines have become an important part of our recommendations to the land manager for lodgepole pine stands threatened by MPB (Bollenbacher and Gibson 1986).

Beginning in 1984, the availability of semiochemicals for MPB provided a tool which made silvicultural treatments even more effective. Aggregative pheromones have the ability to effectively concentrate beetles into stands scheduled for removal (Borden, et al., 1983). Antiaggregative ones, while still being evaluated, may eventually provide a means for protecting high-value stands (Gibson, et al., 1991; Gibson 1994).

To date, management recommendations for MPB address stand conditions rather than beetle depredations, per se. We still recommend "hazard rating" of host stands--now using a much-improved system developed by Shore and Safranyik (1992). In that way, management activities may be directed, in a preventive strategy, towards stands of greatest susceptibility. Stands adjudged to be high hazard are further subjected to analysis using a "rate of loss" model which fairly accurately predicts the amount of mortality expected in a lodgepole pine stand of certain characteristics, over a 10-year infestation period (Cole and McGregor 1983). It has been extremely useful in directing silvicultural treatments to those stands in which losses are expected to be greatest. Once stand hazard and anticipated loss (risk) have been assessed, we recommend analyzing the best alternative for that stand(s) in the larger context of its associated drainage, landscape, or ecosystem. Ultimately, the best mix of treatments will be those which create a mosaic of age and size classes and combination of species best suited to sites in the analysis area. The final objective is to create, or maintain, a healthy forest ecosystem--not entirely devoid of pests--but one in which pest-caused mortality is balanced in such a way that no derived amenities of the system are threatened (McGregor and Cole 1985).

Because we believe the state of our knowledge regarding management of lodgepole pine stands to reduce losses to MPB is, if not perfected, sufficient to prevent large-scale mortality; we envision only minor modifications in our methods in the future. Perhaps the refinement of "hazard-rating" systems to better define stand susceptibility; and the development of more accurate computer models to describe "stand risk" (potential beetle-caused mortality) will enable us to more adequately prioritize stands for preventive treatments. Though there may be times when truly "suppressive" activities are warranted, the greatest long-term benefit will almost always be realized through the prevention of MPB outbreaks by silviculturally altering stand susceptibility.

Though MPB populations in the Northern Region are currently much less than in the recent past, we have hundreds of thousands of acres of lodgepole pine which will grow into size and age classes susceptible to MPB within the next couple of decades. We continue to emphasize the need for hazard and risk rating, and stand alteration prior to MPB outbreaks, in order to significantly reduce beetle-caused mortality. Further, we hope that lessons of the past--as we become more adept at "ecosystem management"--will make future treatments even more timely, efficient and effective.

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Silviculture for the Mountain Pine Beetle

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Sets of growing stock level (GSL) plots were established in lodgepole and ponderosa pine stands between 1984 and 1990. Each set typically consisted of four 2.47-acre plots; three plots partially cut to different GSLs and the fourth left uncut to serve as the control. Leave trees within the cut plots were selected on the basis of diameter, spacing, crown development, and visually apparent good health. Tree selection emphasized leaving the best and largest trees as evenly spaced as possible.

The plots in lodgepole pine stands have not been exposed to mountain pine beetle (MPB) epidemic but some sets of plots in ponderosa pine stands have been exposed to a MPB epidemic and others have endemic MPB populations present. Based on observations of MPB activity in the plots in the ponderosa pine stands, stands of GSL 80 or less appear to be relatively safe from the level of mortality commonly associated with MPB epidemics. Such stands are not entirely free of MPB-caused mortality as single trees may be infested, but large groups of MPB-infested trees commonly associated with epidemics have not been observed. Although Sartwell and Stevens (1975) considered GSL 150 to be the threshold for MPB epidemics, observations in some of the plots indicate this threshold may be as low as GSL 120.

The plots in ponderosa pine stands have exceeded 10 years since they were initially cut. As the 10-year interval was passed, the plots were remeasured. Diameter and basal area growth information was developed. Average diameter in the partially cut plots generally increased by 1 inch or more while basal areas generally increased by more than 10 ft.^{2}. Based on this growth information, straight-line projections were made to determine when the various GSLs would cross the GSL 150 and GSL 120 thresholds for MPB epidemics. For one set of plots, GSLs of 100 and less would take 39 or more years to reach the GSL 150 threshold. However if the threshold is lowered to GSL 120, the GSL 100 would reach this threshold in 16 years and the GSL 80 would reach this threshold in 31 years. If reentry is scheduled about every 20 years, then the GSL 100 would be highly susceptible before another cutting could lower its susceptibility.

Because the susceptibility of stands between GSL 80 and GSL 120 has not been adequately determined, the GSL is being raised in each of the partially cut stands whenever possible. Thus, a GSL 60 plot will be raised to a GSL 70, a GSL 80 to GSL 90, and so forth. Over the course of the 10 years since initial cutting, most of the plots have grown beyond the new level of stocking so some trees need to be removed. Whenever possible, the trees designated for removal will be this with the lowest diameter growth rates during the previous 10-year period. Hopefully, future examination of these plots will enable us to determine the susceptibility status of stands with GSLs between 80 and 120, and whether GSL (BA) is really a critical factor in stand susceptibility or just and indicator of competition/spacing.

Use of Plastic Tarp for Control of Mountain Pine Beetle

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The Vail Valley of Colorado is currently in the midst of a mountain pine beetle outbreak. This outbreak started in approximately 1997 and large numbers of lodgepole pine have been killed by the bark beetle. Vail Valley is an important developed recreation site and has a significant urban forest interface.

Both local Forest Service personnel and local landowners have been using the technique known as "tarping" in an effort to reduce local pine beetle populations. The idea behind tarping is that infested host material is gathered together, piled, and covered with clear plastic sheeting. The idea is that the "greenhouse effect" created by the action of solar energy will create a lethal environment for the beetle brood. Although the use of this method has been fairly widespread, there has been little work assessing the effectiveness of this method. Variations on "tarping" include direct solarization (without plastic) where the infested host material is placed in full sun and rotated on a weekly basis. The idea of using fumigants, in particular DDVP, has also been discussed.

A study to assess the effectiveness of tarping was initiated in Vail Valley in the autumn of 1998. The treatments were:

1) Control - Bolts (sections of tree trunks) cut to the same size and length as the test bolts and placed on the sheets of plywood without tarping

2) Tarped in full sun - Bolts will be cut to a length to fit on the sheets of plywood. They were then covered with plastic tarping and placed in full sun exposure.

3) Tarped and fumigated in full sun - Bolts were cut to a length to fit on the sheets of plywood. They were then covered with plastic tarping and placed in full sun exposure. These piles were also subject to fumigation by the addition of DDVP chips.

4) Tarped in partial sun - These bolts were placed in a location where they received approximately one half days full sun, the rest of the day they should be in shade provided by neighboring trees.

5) Tarped and fumigated in partial sun - These bolts were placed in a location where they received approximately one half days full sun, the rest of the day they were in shade provided by neighboring trees. These piles were also subjected to fumigation by the addition of DDVP chips.

There were 3 replications of each treatment. Each of the piles consisted of bolts, 3 deep. The piles were placed on plywood sheets and the edges of the plastic sheeting was attached to the plywood.

Assessment of the treatments was made in late June of 1999, prior to beetle emergence and flight. Bolts were segregated by position within the piles and randomized for sampling. 2 sections of 300 square centimeters of bark from opposite sides of the bolts were removed and inspected for presence of beetle life stages.

The results of this experiment revealed that there was no difference between the various treatments. We were very surprised to see that the DDVP had no effect upon beetle survival, even though the piles were treated with large doses of the fumigant. The treatments using the clear plastic alone also showed no significant differences compared to the controls.

We plan to follow this study up with an additional experiment in the spring of 2000. Tentatively, we plan to assess the effect of treatments applied in late spring rather that late fall. It has been hypothesized that having the fumigant in the piles during the long, cold winter allowed the material to dissipate slowly, and lethal levels were never reached. It is thought that if the material is applied in the late spring the fumigant will be released in larger doses due to the higher temperatures of the early summer. We also plan to try the direct solarization technique. The lack of success of tarping in the Vail Valley trials may have something to do with the altitude of the test site (8,700 ft.) and the relatively cool temperatures associated with this altitude.

Mountain Pine Beetle Susceptibility/Risk Rating and Impact Prediction

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The bark beetle research group of the Canadian Forest Service, Victoria, has been developing decision support tools to assist forest managers in reducing losses to the mountain pine beetle. The primary tools developed so far are a susceptibility and risk rating system, a stand-level population dynamics and impact model and stand and landscape level management options expert systems.

The Shore and Safranyik (1992) stand susceptibility and risk rating system is used widely throughout British Columbia and in some parts of the U.S. Susceptibility is defined as the inherent characteristics of a stand that affect its likelihood of attack and damage by the mountain pine beetle. Risk is defined as the short term expectation of tree mortality in a stand as a result of a beetle infestation, and beetle pressure is defined as the magnitude of a beetle population affecting a stand as determined by the number and proximity of infested trees. Stand susceptibility is based on four variables: age, stand density, location (elevation, latitude, longitude) and percent susceptible pine basal area. Risk is a function of stand susceptibility and beetle pressure. Susceptibility and risk rating systems are used to identify stands with higher risk of damage, and to prioritize stand and beetle treatments.

Impact models have been developed at the landscape and stand levels. For the landscape level a relationship has recently been developed between stand susceptibility and the percentage of a stand's basal area killed by the mountain pine beetle (Shore et al. 2000). This allows for broad scale estimation of potential losses if no management intervention is taken. At the stand level a detailed population dynamics and impact model called MPBSim has been developed. Given initial inputs of the number of trees attacked and some stand parameters the model estimates the duration of the infestation and tree mortality on an annual basis. The model also tracks population levels on an annual basis. This information is currently being used in the development of a more detailed landscape level spread and impact model.

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Mountain Pine Beetle in Lodgepole Pine Hazard Rating for the Forest Service's New Ibm System

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Background

Hazard is defined as the ability of a stand to support a growing population of mountain pine beetles. Hazard is defined by 2 factors: the quality and the quantity of susceptible lodgepole pine.

The quality of the lodgepole component of a stand as a mountain pine beetle food source is best characterized by two things: stand density and lodgepole pine phloem thickness. In addition, the location of a stand also has a bearing on mountain pine beetle success. If lodgepole pine is growing in cold, high areas, the mountain pine beetle is less likely to be successful because it takes the beetle longer to complete its life cycle.

The quantity of the food source refers to the species composition and density of the forest. A pure, well stocked lodgepole stand will be more likely to support a large mountain pine beetle population than a mixed species and / or poorly stocked stand.

Two mountain pine beetle hazard rating systems are available on computer for land managers to use: 1) the Amman et al. (1977) system as automated on the data general system by Wayne Bousfield; and 2) the Shore and Safranyik (1992) system available on personal computers. Both systems have been widely used, but neither allows the rapid assessment of hundreds of stands across a landscape.

As part of the St Joe River Basin Geographic Area Assessment currently underway by the Idaho Panhandle National Forests, we employed the two currently available systems to hazard rate a number of lodgepole pine stands in the basin. After ground checking our results, and encountering a number of tactical problems with the existing computer programs, we decided to modify the hazard systems, include another parameter in hazard calculation, and create a new computer program which would take advantage of tools in the Forest Service's new IBM system which work together to make data and data analysis more accessible to the users.

New IBM System

From our experience using the other systems and ground checking the results we were able to determine what we wanted from a new system. We wanted to develop a system which would not rely too heavily on age, as age in the database is of dubious quality. We wanted to include basal area in hazard determination. In our guidelines to reduce mountain pine beetle hazard we suggest reducing basal area to below 80 square feet to reduce beetle hazard, and we warn managers that stands with greater than 100 square feet of basal area may be at increased risk. We found when basal area was not expressly used in a rating, stands with low basal area sometimes were assigned high hazards. Finally, we wanted output which would include stand information that could be readily summarized and incorporated into reports and GIS databases.

The Idaho Panhandle National Forests have placed their timber stand management record system into an Oracle data base on the IBM system. Using Oracle's PL/SQL procedural language we created a query which sequentially sifts stands into different hazard classifications per the logic below:

Query Format- Geographic Area Assessment Level Data

MPB Query Format- Geographic Area Assessment Level Data

```
  If % BA Lodgepole Pine = 0                                  Then  Hazard = 0 Very Low
            else
  If % BA Lodgepole Pine < 25                                 Then  Hazard = 1 Low
            else
  If Stand BA < 80 or > or = 250                              Then  Hazard = 2 Low
            else
  If # Tree per Acre > 3" DBH < 100 or > 800                  Then  Hazard = 3 Low
            else
  If Average DBH Lodgepole Pine > 5" DBH is < 6" Then  Hazard = 4 Low
            else
* If Subcompartment = .........                               Then  Hazard = 4.5 Low
            else
& If Stand Age is <60  or >250                                Then Hazard = 4.75 Low
            else
  If % BA Lodgepole Pine is 25-50%                            Then  Hazard = 5 Moderate
            else
  If Stand BA is 80-100 or 200-250                            Then  Hazard = 6 Moderate
            else
  If # Trees per Acre > 3" DBH 100-225 or 600-800  Then Hazard = 7 Moderate
            else
  If Average DBH Lodgepole Pine > 5" DBH is <8"  Then  Hazard = 8 Moderate
            else
* If Subcompartment = ..........                              Then  Hazard = 9 Moderate
            else
& If stand age > or = 60 but <80 or > or =180 but <250        Then Hazard = 9.5 Moderate
            else
                                 Then  Hazard = 10 High
```

* These two clauses require information from outside TSMRS. These clauses

allow the incorporation of location into hazard calculation. Elevation, Latitude, and Longitude are not included in TSMRS, but are available from other sources. For the St Joe GA average subcompartment elevations, latitudes, and longitudes were used to calculate a location hazard factor by subcompartment per Shore and Safranyik (1992). If the location hazard factor was low, the subcompartments were listed in the first clause and given a hazard rating of 4.5- Low. If the location hazard factor was moderate, the subcompartment was listed in the second clause and given a hazard rating of 9- Moderate.

& When the program is run users have the option of including age in hazard calculation. If users decide to include age data, these clauses apply.

This rating, in addition to a number of parameters germane to the calculation and interpretation of mountain pine beetle hazard, is then captured in a new Oracle database. The information in the new database enables managers to know not only if a stand is susceptible to mountain pine beetle, but why. For example if a stand has a hazard rating of 2, we know that it is a low hazard stand because stand basal area is lower than 80. If another stand had a hazard rating of 1, we know that the stand is a low hazard stand because less than 25 % BA of the stand is lodgepole pine.

Perhaps one of the most useful features of the IBM hazard rating system is the integration of Oracle databases and ESRI's ArcView GIS software. In ArcView, the mountain pine beetle hazard database is joined to timber stand polygon coverage to provide a spatial representation of the mountain pine beetle hazard for a user defined area. This enables managers to visualize where on a landscape the most susceptible lodgepole pine stands are situated facilitating landscape level planning efforts and helping managers prioritize potential treatment areas.

The Use of Hazard Ratings in Landscape Level Assessments

Considerations

This analysis assumes that the stands contained in the TSMRS database are a representative sample of the range of conditions in the landscape. A number of stands may not be in TSMRS or have insufficient data for query processing. District personnel are strongly encouraged to carefully look at the stands rated to judge how well this assumption is met.

Hazard rating also assumes stands are homogeneous. If there is variability within the stand in any of the parameters used to determine hazard, the system is unable to detect it and adjust the hazard accordingly.

This system provides the user with printouts of stand characteristics. No attempts have been made to "grow" stands from the date of the exam to the current date. It is important to consider the age of the data when interpreting hazard. Many of the characteristics of the stand used in hazard determination may have changed between the time of the exam and today. As always, it is prudent to ground check results.

Appropriate Use of Hazard Map

Hazard maps produced from data from the query are powerful tools for managers and planners at the geographic area assessment level. Such maps help managers identify areas which may experience significant mountain pine beetle mortality.

Hazard rating does not predict when or even if the mountain pine beetle will be active in a certain stand. Experience has shown that beetles will eventually infest high hazard stands, but it is impossible to predict when.

Hazard rating can not predict stand losses from mountain pine beetles. Hazard ratings address the quality and quantity of food available to the beetle, but does not address beetle populations. In order to address loss it is necessary to collect additional data about beetle populations at the stand level and run a loss prediction model such as the insect and disease detection survey (INDIDS) (Bousefield 1980) or pest extensions to the forest vegetation simulator.

What Next: Project Planning

A hazard map is the easiest way for managers to quickly identify areas with a high quantity of quality food for the mountain pine beetle, thus the areas most likely to experience significant mountain pine beetle impacts. Once areas are identified, more information is needed.

Hazard is the combination of quantity and quality, in order to plan a project managers need consider these factors individually on a stand by stand basis. The manager should also consider the current level of beetle pressure in the area. Beetle pressure is the magnitude of a mountain pine beetle population affecting a stand as determined by the number of currently infested trees and their proximity to the stand being assessed. Beetle pressure is a dynamic variable and may change quite suddenly due to factors such as adverse or favorable weather conditions or immigration of beetles from another location. For this reason the beetle pressure should be reviewed every year or two.

At most project levels the assumption that the stands are homogeneous is no longer appropriate. Additional information from a variety of sources, including recent walk throughs, aerial photography, insect aerial detection surveys and models runs (INDIDS and the mountain pine beetles extension of the Forest Vegetation Simulator) should be gathered to help determine which stands are most critical for treatment.

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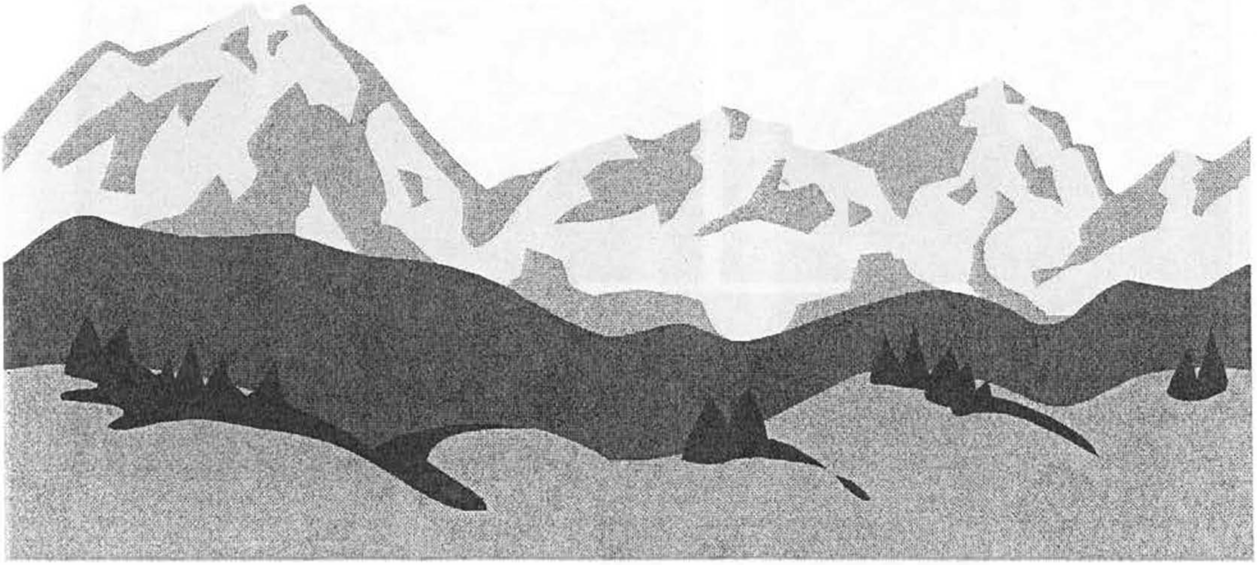

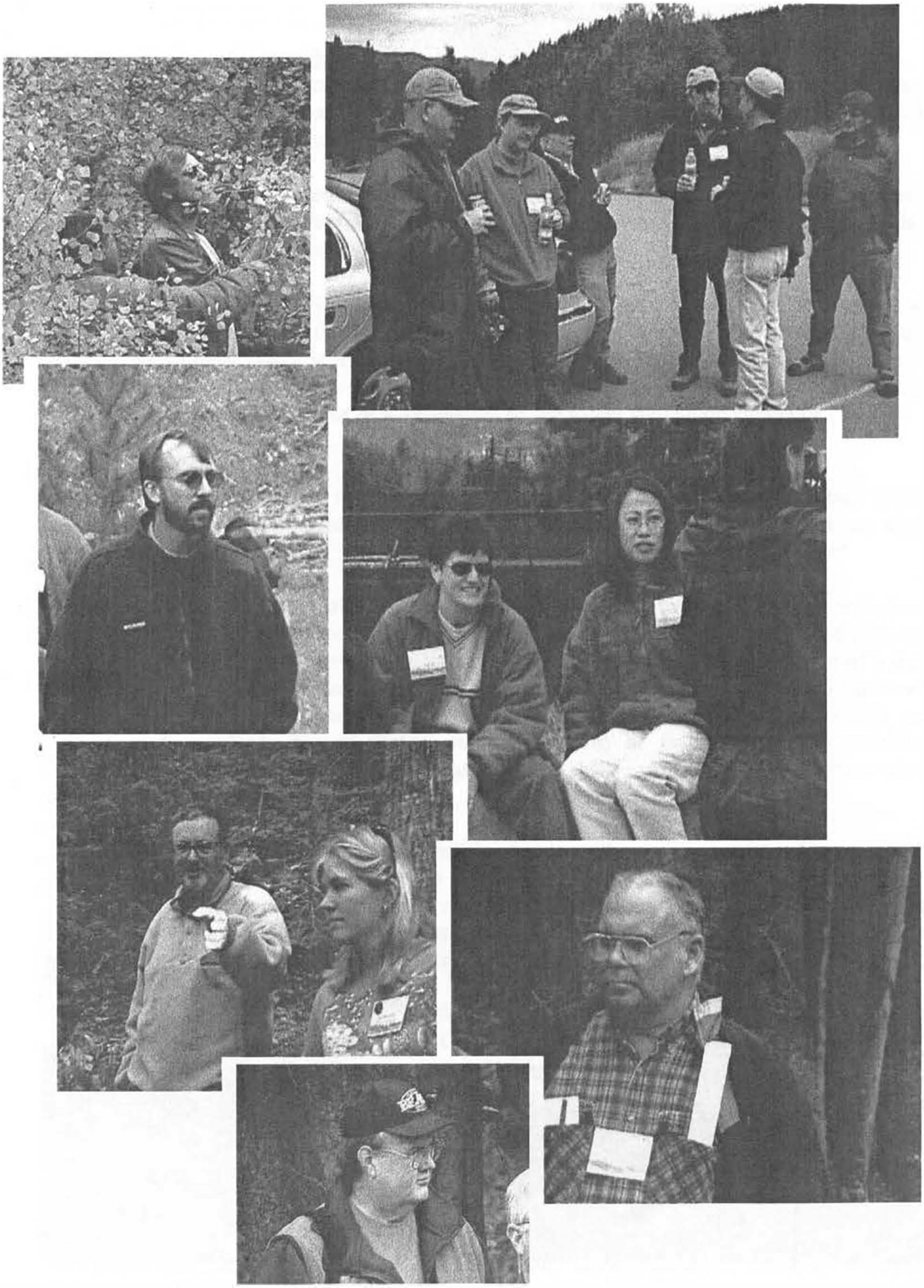

Kairomonal Response of *Monochamus clamator, M. scutellatus*, and *M. obtusus* to Sympatric Bark Beetle Pheromones.

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Wood-boring beetles cause annual losses in excess of 44 million (US) to the BC forest industry. Current trapping programs with host volatiles are inadequate and need to be improved. Bark beetles and wood-boring beetles have overlapping host ranges and similar brood requirements. We hypothesized that sympatric bark beetle pheromones may function as indicators of potential wood-borer habitat and consequently may play a significant role in wood-borer host selection. Nine antennally active candidate pheromone components were identified using gas chromatographic-electroantennographic detection (GC-EAD) analysis for *Monochamus scutellatus, M. clamator* and *M. obtusus*. The pheromone components were divided into two groups based on their threshold concentration for antennal activity. Field trapping experiments tested the behavioural response of wild *Monochamus* spp. to the antennally active pheromone groups. Preliminary analyses of trap catches suggest that the pheromone group of MCH, Frontalin, Ipsenol and Ipsdienol is significantly more attractive than the unbaited control.

Reproductive Potential of the Mountain Pine Beetle, *Dendroctonus ponderosae* Hopkins, in Whitebark and Lodgepole Pine

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Introduction

Whitebark pine, *Pinus albicaulis*, is a slow-growing, long-lived, high-elevation tree species. Its geographic range extends from central California and western Wyoming north to British Columbia and Alberta. Whitebark pine forests generally occur on poorly developed soils in cirque basins and on windswept ridges. Where established, whitebark pine stabilizes soil, rock, and snow on steep slopes (Arno and Hoff 1989).

Whitebark pine is a monoecious conifer with indehiscent cones that bear large wingless seeds. The Clark's nutcracker is the primary dispersal agent of the seeds, and therefore, a critical component in regeneration. Although it has limited use as a commercial timber species, whitebark pine is an important food source for the North American grizzly bear (*Ursus arctos horribilis*) and other wildlife species (Arno and Hoff 1989). Unfortunately, whitebark pine is in rapid decline.

In large portions of its range, whitebark pine is threatened by three major factors: (1) fire suppression which has allowed the encroachment of shade-tolerant subalpine fir into stands of shade-intolerant whitebark pine; (2) white pine blister rust, an introduced disease from Europe; and (3) the mountain pine beetle, *Dendroctonus ponderosae* Hopkins, a native aggressive bark beetle that kills whitebark pine by attacking trees already weakened by blister rust or by spreading into whitebark stands from outbreaks that develop in adjacent stands of high elevation lodgepole pine (Amman 1982, Baker et al. 1971; Arno and Hoff 1989).

The mountain pine beetle is indigenous to western United States and Canada. It infests 13 North American pine species and displays host specificity in which it completed development between lodgepole and whitebark pine species (Baker et al. 1971). Its ability to kill healthy mature trees has earned it as the most destructive bark beetle in western North American forests (De Leon 1934, Furniss and Carolin 1977). The mountain pine beetle is the forest insect believed to have the most impact on whitebark pine (Arno and Hoff 1989, McCaughey and Schmidt 1989).

There are an array of factors affecting mountain pine beetle reproductive success: outer bark and phloem thickness, severity of winter conditions, drying of phloem and sapwood during larval development, natural enemies, fungal associates, and inter- and intra-specific competition. Bark thickness, and particularly, phloem thickness as well as tree diameter affect the insulating capacity and drying of sapwood directly affecting beetle brood development. Drying is more severe in small diameter trees and trees experiencing greater beetle attack densities (Amman and Cole 1983). Phloem thickness is positively correlated with tree diameter (Amman 1969) and tree vigor (Cole 1973) and is highly correlated with beetle brood success (Amman 1972; Berryman 1976). Whitebark pine has thicker phloem than lodgepole pine of similar diameters at high elevation sites (Baker et al. 1971) so potentially may support greater bark beetle populations.

Bark beetles are symbiotically associated with fungi. The fungal associates of a given bark beetle species can have strong positive or negative effects on the beetle's reproductive success, and therefore, may influence beetle population dynamics. The mountain pine beetle is associated with two mycangial fungi, *Ophiostoma clavigerum* and *O. montium* (Whitney and

Farris, 1970). These fungi differentially affect the reproductive potential of their host beetle. Brood production is significantly greater for beetles developing with *O. clavigerum* than for beetles developing with *O. montium*. Brood production in the presence of *O. montium* is very poor, barely exceeding the parental replacement rate (Six and Paine, 1998).

Historically, the mountain pine beetle has infested extensive areas of lodgepole pine forests in Idaho and Montana. These outbreaks developed in low-elevations and moved into high-elevation whitebark pine zones (Baker et al. 1971,Ciesla and Furniss 1975, Arno and Hoff 1989). However, Evenden (1933) noted an instance where mountain pine beetle cause significant mortality in whitebark pine while surrounding pine stands remained relatively uninfested. Therefore, it is unclear whether mountain pine beetles cause significant damage in whitebark pine except when beetles disperse into stands from adjacent or lower elevation stands of lodgepole experiencing beetle outbreaks.

This study will investigate the population dynamics of mountain pine beetle in whitebark pine and adjacent lodgepole pine stands. Specific objectives include: evaluating the reproductive potential and the mortality factors that impact the reproductive potential of the mountain pine beetle in whitebark and lodgepole pines. Currently, little information exists on factors affecting reproductive potential and mortality of mountain pine beetle in high-elevation ecosystems. Knowledge of these factors in whitebark pine and in surrounding stands of lodgepole pine would provide important information on where the beetle is able to actually reproduce to a degree that it can sustain an aggressive population. Understanding whether the beetle can reproduce in whitebark pine at a rate that would allow increases in population size will tell us whether management will need to be focused in the whitebark pine ecosystems or strictly in adjacent stands of lodgepole pine. Finally, this research will provide basic knowledge on the mountain pine beetle in high-elevation stands of whitebark pine and lodgepole pine.

Materials and Methods

In the summer of 1999, study sites were located near the central panhandle of Idaho at Nut Basin and Burnt Knob on the Nez Perce National Forest, and at Point Six and Cabin City on the Lolo National Forest northwest of Missoula, Montana. At each site, the following characteristics were assessed: vegetation and stand characteristics, habitat type, elevation, slope, and aspect. Temperatures are being recorded at each site for the duration of the project.

Beetle populations were sampled according to the method of Carlson and Cole (1965). Two bark samples, (232 cm^2, one each from the north and south aspect of the tree) were removed from each tree at each of 2 heights, [1.5 m ($\pm$30 cm) and 3.5m ($\pm$30 cm)], on the bole. Outer bark and phloem thickness, and sapwood moisture were measured for each sample. The number of eggs, niches, and larvae in each sample were counted egg gallery length measured. A blister rust rating was also done for each tree. After sampling, a pruning sealant was sprayed over the bare wood where the sample was removed to inhibit drying. This sampling procedure will resume in year 2000, once in late spring/early summer after overwintering but prior to beetle emergence, and again in late summer/early fall after emergence is complete. Cages (with collecting tubes attached) covering 930 cm^2 of bark surface will be placed on the trees after the post-wintering samples are complete to collect emerging adult beetles. Emerging adults will be collected from the cages every two days, sexed, and the length of each beetle and the width of its pronotum measured as an assessment of relative beetle fitness. After emergence is complete, the cages will be removed to allow the post-emergence sample to be taken.

For each tree, we will assess reproductive potential, and mortality factors accounting for the death of any beetles in the sample. Reproductive potential will be assessed by comparing the number of eggs laid (determined by counting number of eggs and egg niches along walls of egg galleries) to the actual number of adults produced (as estimated by emergence in cages), the sex-ratio produced (a higher female to male ratio equates to greater future offspring production), and progeny beetle size (larger beetles are more reproductively fit). Nine mortality factors impacting reproductive potential will be evaluated: intra- and inter-specific competition, parasitoids, predators, pathogens, temperature, drying of phloem, presence of pitch, and the unexplained mortality (Amman 1984). We will also look for correlations between sapwood moisture, phloem thickness, and reproduction.

Mycangial fungi will be isolated from the beetles collected from emergence cages. The fungi will be isolated by surface sterilizing the beetles in White's solution (Barras 1972) and then dissecting out the mycangia and embedding them into malt agar (Six and Paine 1996). Fungal associates will be identified and voucher strains deposited in the American Type Culture Collection (Bethesda, MD).

Results and Discussion

Differences in reproductive potential of the mountain pine beetle in whitebark and lodgepole pine may attributed to tree diameter, phloem thickness, and sapwood moisture. The larger the tree, the larger the ratio of emerging adults to parents attacking and killing the tree, all of which is related to tree diameter and phloem thickness (Cole and Amman 1969). The average phloem thickness for whitebark pine is nearly double that of lodgepole pine (Table 1). Therefore, we might expect greater reproductive potential in whitebark than in lodgepole pine.

Sapwood moisture is essential for the development of the mountain pine beetle. After a tree has been successfully attacked by the beetle, moisture content in the sapwood drops, thus influencing egg gallery establishment and brood survival (Reid 1962). The average sapwood moisture is greater in lodgepole pine than whitebark pine (Table 1). Therefore, we might expect an increased survival rate with the higher moisture content of the sapwood in lodgepole pine trees.

Sampling procedures will resume in year 2000 and data will be evaluated for the reproductive potential of the mountain pine beetle in whitebark and lodgepole pine.

Table 1. Average values on lodgepole and whitebark pine host trees and mountain pine beetle broods.

Tree species	Site	Avg DBH, cm (SE)	N	Avg bark thickness, cm (SE)	Avg phloem thickness, cm (SE)	Avg % sapwood moisture (SE)	N	Avg # eggs per cm gallery (SE)	N
LPP*[1]	CC[3]	28.37 (1.08)	6	0.58 (0.04)	0.17 (0.01)	38.82 (2.70)	17	1.52 (0.24)	12
WBP[2]	NB[4]	37.51 (3.12)	11	0.42 (0.02)	0.31 (0.03)	31.35 (0.73)	43	1.69 (0.09)	38
	BN[5]	29.45 (2.56)	3	0.35 (0.03)	0.31 (0.03)	28.55 (0.61)	11	1.68 (0.11)	7
	PS[6]	22.00 (0.58)	3	0.36 (0.02)	0.34 (0.03)	29.20 (1.04)	10	Data not available	

* Additional lodgepole pine stands to be added in year 2000.

[1] Lodgepole pine

[2] Whitebark pine

[3] Cabin City, Lolo National Forest

[4] Nut Basin, Nez Perce National Forest

[5] Burnt Knob, Nez Perce National Forest

[6] Point Six, Lolo National Forest

Acknowledgements

We would like to thank the following for their valuable assistance: Ken Gibson and Tim McConnell, USDA Forest Service, Northern Region; Joe Kipphut, USDA Forest Service, Lolo National Forest; Jennifer Nelson, USDA National Forest, Nez Perce National Forest; and Michelle Byington, University of Montana, School of Forestry.

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Assessing Bark Beetle Risk in Whitebark Pine Restoration Programs.

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Whitebark pine (*Pinus albicaulis*) is a five-needled pine with a large wingless seed that grows at high elevations throughout the northern Rocky Mountains. At the upper reaches of timberline habitats, whitebark pine is often the only tree species, due to harsh, windy conditions and dry, rocky soil. An integral component of these ecosystems, whitebark pine helps prevent erosion, retain snowpack, and provides aesthetics. Many wildlife species forage on the large seed, including grizzly bears, black bears, red squirrels and various birds (Kendall and Arno 1990). The Clark's nutcracker, a member of the jay family, has developed a symbiotic relationship with whitebark pine. The nutcracker caches whitebark seeds underground, to serve as a food source later. Un-recovered seed caches are responsible for the majority of whitebark pine regeneration (Tomback 1982).

Whitebark pine is declining across most of its range, due to three main factors and their interactions (Kendall and Arno 1990). One factor is white pine blister rust (*Cronartium ribicola*), a disease introduced from Europe in the early part of this century. The rust, which tends to top-kill trees before eventually causing tree mortality, has infected up to 90% of the whitebark pine in some stands in western Montana. Extensive top-kill may lead to a declining cone crop, which negatively impacts regeneration. Another factor leading to the decline is the mountain pine beetle (*Dendroctonus ponderosae*), a native insect that can outbreak in stands of whitebark pine. Mountain pine beetle outbreaks tend to kill the majority of trees over 12 inches in diameter, leaving mainly trees that are not yet producing a cone crop. The third factor leading to the decline is fire suppression. Fire suppression began around 1900 and has allowed more shade tolerant species, such as subalpine fir (*Abies lasiocarpa*) and Engelmann spruce (*Picea engelmannii*), to out-compete the more shade intolerant whitebark pine. In addition, the Clark's nutcracker prefers open areas to cache seeds. Such open areas are few due to the dense conditions created by fire suppression. Interactions among these three factors have resulted in a severe decline of whitebark pine.

In the early 1990's, the USDA Forest Service began a whitebark pine restoration program at several sites in Montana and Idaho (Keane and Arno 1996). Designed by researchers at the Intermountain Fire Sciences Lab in Missoula, MT, these sites utilize a variety of silvicultural treatments and prescribed fire to enhance survival and regeneration of whitebark pine. The restoration site used in this study is located at Beaver Ridge, in the Powell Area of the Lochsa Ranger District of the Clearwater National Forest, ID. The site is located about 65 miles southwest of Missoula, MT. Implementation of restoration treatments at Beaver Ridge began in July 1998, and culminated in prescribed burning in September 1999.

Historically, whitebark pine has not been the focus of research (Keane et al 1994). It is not a commercial timber species and is often located is areas inaccessible by car. Only in the past several years has interest in whitebark pine increased. Therefore, the insects, particularly bark beetles, associated with whitebark pine are not well characterized. This study will add to the knowledge base about whitebark pine and address some important issues regarding the management and restoration of the species.

Objectives were to document: 1) the bark beetle species attacking whitebark pine, 2) changes in the bark beetle populations after implementation of the restoration treatments, and 3) the flight periods of *D. ponderosae* and *Ips pini* in this high elevation ecosystem.

METHODS

Circular 1/10th acre fixed plots were located throughout each treatment area using a systematic grid. For the purposes of this study, seven treatment areas were identified: Nutcracker openings with and without prescribed fire, slashing with and without prescribed fire, stand replacement burn with and without slashing, and a control. Each plot center was marked with a permanent rebar stake. GPS position was then recorded at the plot center. Other plot level data recorded included slope, aspect, habitat type, and canopy cover. Tree data taken included height, diameter at breast height, obvious tree features, such as damages, forks and incidence of disease, and distance and azimuth to plot center. For each whitebark pine, a severity rating was assigned for white pine blister rust. These data will be analyzed using logistic regression during the winter 1999-2000.

After the permanent plots were established, a bark beetle survey was conducted. Presence/absence of any bark beetles on all trees was recorded. Additional information was recorded for those trees with beetles present. This included beetle species, whether the attack was successful, and number of attacks occurring in a 10-cm wide circle around the tree bole at breast height. Similar bark beetle surveys were conducted on 70 permanent plots established by the Forest Service. These plots also consisted of 1/10th acre fixed plots, and were surveyed in September 1998 and 1999.

To monitor mountain pine beetle and pine engraver flight periods, pheromone-baited traps were hung outside the treatment areas. Trap catches indicated when flights were essentially completed, allowing the bark beetle survey to begin. Trap catches also gave a general picture of the flight pattern at the study site. It should be noted that the *Ips pini* trap did not attract any bark beetles (traps were probably placed after flights were completed), so only information on the mountain pine beetle flight is available.

RESULTS

Preliminary results include the flight period for the mountain pine beetle in 1999 (Fig.1). Monitoring began on July 19 and traps were monitored approximately weekly thereafter. The decrease in trap catches in August is probably due to temperature; the study site experienced a week of cold, wet weather during this period. Temperature data for the area during the trapping period will be examined and is expected to show a similar pattern.

Four species of bark beetle have been collected and sight-identified from whitebark pine. These include the mountain pine beetle, the pine engraver (*Ips pini*), the red turpentine beetle (*D. valens*), and a secondary, *Pityogenes fossifrons*. Of these four beetles, only the mountain pine beetle and *P. fossifrons* have previously been recorded in whitebark pine. The pine engraver and the red turpentine beetle are typically associated with fresh slash and stumps; both can be found in the nutcracker opening treatments at Beaver Ridge. The mountain pine beetle was found strictly in whitebark pine, even though a large number of lodgepole pine were sampled. It appears this beetle can maintain endemic populations in whitebark pine. *P. fossifrons* was found only on sapling-size whitebark pine, primarily in the nutcracker openings. Although it typically attacks stressed or weakened trees, it did attack and kill trees under little apparent stress at Beaver Ridge.

CONCLUSION

Whitebark pine is a major component of high elevation ecosystems in the western United States. Restoration of the species may require treatments and landscape changes that these ecosystems have never experienced, such as cutting. This study measured changes in bark beetle populations after restoration treatment implementation. It is important to understand the implications of the treatments upon bark beetle populations so that any resulting negative effects can be mitigated through proper management techniques.

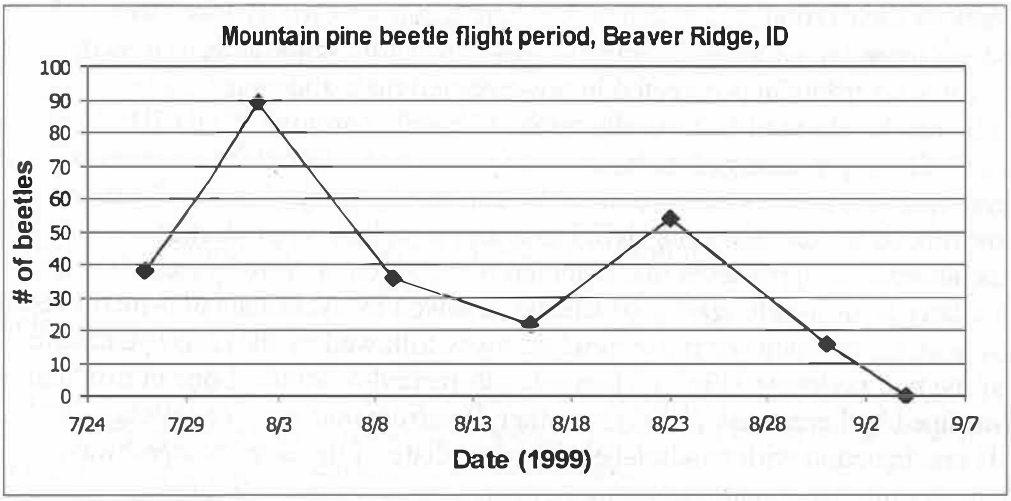

Figure 1. 1999 flight period for the mountain pine beetle, Beaver Ridge, ID.

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Pheromone Synthesis in *Dendroctonus*

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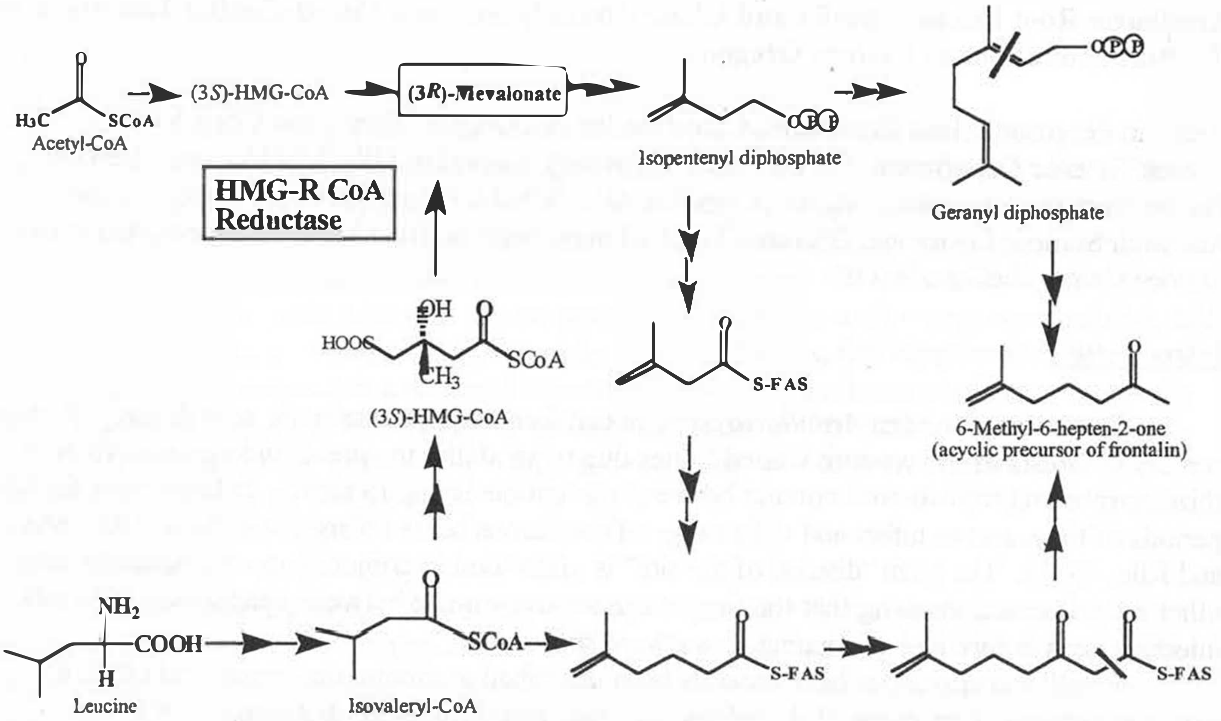
Bark beetle species in the genus *Dendroctonus* mass attack host conifers in large numbers in order to successfully colonize the trees. In this genus, the mass attack is coordinated by potent species-specific aggregation pheromones. The Jeffrey pine beetle, *Dendroctonus jeffreyi* Hopkins, is monophagous on Jeffrey pine, *Pinus jeffreyi* Grev. & Balf., a high elevation pine that occurs in the Sierra Nevada Range. The working blend of compounds that is thought to make up the *D. jeffreyi* aggregation pheromone includes *n*-heptane (produced by *P. jeffreyi*), 1-heptanol (produced by the pioneering females exposed toheptane), and frontalin and *exo*-brevicomin, two bicyclic acetals produced by the males (Renwick and Pitman, 1979; Paine *et al.*, 1999). Females also produce *trans*-verbenol, verbenone, and, following exposure to heptane, large quantities of ~88%-(+)-2-heptanol following exposure to heptane (Barkawi *et al.*, unpublished).

Frontalin and *exo*-brevicomin are likely synthesized *denovo* by males as they emerge as adults through the bark of their brood tree to follow the female into a newly-attacked tree. Emerged males produce frontalin, which is detected by gas-chromatographic analysis in extracts of abdominal tissue, while no frontalin is detected in pre-emerged male abdominal tissue. Production of frontalin can be elevated by topically-applied juvenile hormone III (JHIII). Topical application ofJHIII to pre-emerged males induces production of frontalin by emerged males of the same enantiomeric ratio as that produced by untreated, emerged males. Thus, we have studied the biosynthesis of frontalin using JHIII as a tool to induce its production.

We tested the alternative hypotheses that frontalin is produced *de novo* by male *D. jeffreyi* through (1) a fatty acid-like elongation of leucine followed by cyclization of 6-methyl-6-hepten-2-one to frontalin, (2) through the is oprenoid pathway followed by the same cyclization, or (3) by a hybrid of the two pathways (Fig.1). The role of6-methyl-6-hepten-2-one in frontalin synthesis has been outlined by Perez*et al.* (1996) for other *Dendroctonus* spp. Following treatment with JHIII and injection with a radiolabeled intermediate of the isoprenoidpathway, *RS*-[2-^{14}C]-mevalonolactone (an acyclic form ofmevalonate), emerged male *D. jeffreyi* produced radiolabeled frontalin.3-Hydroxy-3-methylglutaryl coenzyme A reductase (HMG-R) is an enzyme thatregulates the isoprenoid pathway (Goldstein and Brown, 1990). We also found that topical application of JHIII on male *D. jeffreyi* elevated the mRNA levels of *HMG-R* in a way that parallels the elevation of frontalin production following JHIII treatment. Together, the labeling of frontalin from an isoprenoid intermediate as well as the up-regulation of *HMG-R* gene expression in male *D. jeffreyi* treated with JHIII provide preliminary support for hypotheses 2 or 3, *i.e.* that male *D. jeffreyi* synthesize frontalin via at least some isoprenoid pathway reactions.

We have also begun investigating the production of semiochemicals in two populations of spruce beetle, *Dendroctonus rufipennis*(Kirby). Frontalin has been reported to be found in female abdominal tissue (Pitman and VitŽ, 1970). In preliminary analyses of extracts from one Utah and one Colorado population, we have not been able to detect frontalin in abdominal extracts from JHIII treated and untreated males or females. We will continue to analyze these extracts by gas chromatographic/mass spectrometry to specifically look for compounds likely to be semiochemicals such as verbenols or cyclohexenone derivatives.



Acetyl-CoA
(3S)-HMG-CoA
(3R)-Mevalonate
HMG-R CoA Reductase
Isopentenyl diphosphate
Geranyl diphosphate
(3S)-HMG-CoA
S-FAS
6-Methyl-6-hepten-2-one (acyclic precursor of frontalin)
Leucine
Isovaleryl-CoA
S-FAS
S-FAS

d.

Figure 1. Alternative hypothetical pathways for frontalin biosynthesis.

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Armillaria Root Disease Species and Clone Diversity Across a Mixed-Conifer Landscape in the Blue Mountains of Eastern Oregon

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Introduction

The forest pathogen *Armillaria ostoyae* can form large, contiguous, root disease infection centers in forests of the western United States due to an ability to spread underground via both rhizomorphs and root-to-root contact between susceptible hosts, to survive in large roots for long periods of time, and to infect and kill a range of coniferous hosts (Wargo and Shaw, 1985; Shaw and Kile, 1991). The term "disease of the site" is often used in conjunction with Armillaria and other root diseases, meaning that the fungus can survive on-site between generations of forests, infecting each in turn and continuing its outward spread.

Armillaria sp. clones have recently been described as among the largest and oldest of extant organisms. One clone of *A. bulbosa* in a hardwood forest in Michigan was shown to cover 37 ac (15 ha) and estimated to be perhaps 1500 years old (Smith et al., 1992). The genetic stability of such large clones has been called remarkable (Braiser 1992), although comparison of such fungi to large organisms that exhibit a more determinate growth form, such as redwood trees or blue whales, is questioned.

Previous studies in the coniferous, eastside forests of Oregon and Washington have reported large clones of pathogenic *Armillaria.* Adams (1974), working in ponderosa pine forests in central Oregon, used vegetative plate pairings to distinguish clones of *A. mellea* (*sensu lato*). He found one clone with a minimum width of 0.9 mi (1.45 km), and two with widths of 0.5 mi (0.8 km). Assuming idealized, round infection centers, these may have occupied upwards of 410 ac (165 ha) and 195 ac (79 ha), respectively. Other work using isolates from an Armillaria root diseased ponderosa pine forest in Washington revealed that one clone of *A. mellea* (*sensu lato*) was a minimum of 800 m in diameter, equivalent to an idealized infection center of 125 ac (50 ha) (Shaw and Roth, 1976).

Root disease surveys have been performed on portions of our study area over the last 18 years. Each time, Armillaria root disease was identified as the primary cause of mortality (Schmitt 1990; Schmitt and Kanaskie, 1982). Mortality centers range from very small to tens of acres. Many appear to be discrete, with apparently non-infected areas between. However, suspicion grew in the mid 1980's that this area harbored large clones of *A. ostoyae* (Craig Schmitt, personal communication). Our study was initiated in 1998 to determine the species and clonal diversity of *Armillaria* across an Armillaria root disease-infected, mixed-conifer landscape in the Blue Mountains of Oregon.

Methods

Study Area

The study took place in an Armillaria root diseased, mixed-conifer forest in the Blue Mountains of eastern Oregon, on the Prairie City Ranger District of the Malheur National Forest. The study area encompasses approximately 64 square miles, although sampling was concentrated within half that. Elevation ranges from 5000-6500 ft over predominantly steep topography. The forest is comprised of Douglas-fir (*Pseudotsuga menziesii*), grand fir (*Abies grandis*), lodgepole pine (*Pinus contorta*), ponderosa pine (*Pinus ponderosa*), western larch (*Larix occidentalis*), and subalpine fir (*Abies lasiocarpa*). Typical of many east-side forests, fire suppression and selective harvest has resulted in a scattered overstory of western larch and ponderosa pine, with dense Douglas-fir and grand fir beneath. It is likely that recurrent ground and occasional stand replacement fires maintained much of this area in more open, low density, seral species-dominated stands than we see today.

Field Sampling

A nested sampling design was employed in 1998 in order to examine the diversity of *Armillaria* species and clones within individual infection centers, among infection centers within stands, among stands, and among watersheds. Collections took place from stands within three large, previously identified areas of Armillaria root disease, and took place from late July to early August. Within each stand, 2-3 separate infection centers were sampled by making a collection from 1-2 trees in each. Most collections took place within 300 ft (91.5 m) of forest roads. Samples were taken from live trees showing root disease symptoms or trees that had been dead 1-4 years.

Field collections in 1999 were used to fill gaps within clones identified using the 1998 isolates, as well as to better define their boundaries. Fourteen sites were sampled during June 15-18, but not using the nested sampling design of 1998.

Isolations

Samples collected in 1998 were isolated on 3% malt extract agar (45g malt extract agar, 1l dH_2O). The 1999 isolates were isolated on the media used for vegetative plate pairings (30g malt extract, 20g dextrose, 5g peptone, 19g agar, 1l dH_2O). Three freshly exposed wood chips were placed on each plate, and the plates were stored in the dark at room temperature until pure cultures were obtained. Working cultures were maintained in the dark at room temperature on the plate pairing media during the course of the study.

Species Identification

Species identity of isolates were confirmed using two methods. The first was a PCR-based method (White et al., 1998), and the second, developed by McDonald and Martin (1988), utilized vegetative plate pairings between isolates. Tester isolates of the two *Armillaria* species most likely to occur in our study area, *A. ostoyae* and North American Biological Species X (NABS-X), were used as standards (Dr. Geral McDonald, personal communication). One *A. ostoyae* tester was collected from western redcedar (*Thuja plicata*) on Vancouver Island, BC (Dr. Duncan Morrison, personal communication), and the second *A. ostoyae* and the one NABS-X tester came from the collection of Dr. Gerald McDonald.

The PCR-based diagnostic on the tester species and all isolates collected in 1998 was performed at a USDA Forest Service lab in Corvallis, OR. The diagnostic was replicated on the tester species and a subset of the isolates at the University of California, Davis. White et al.'s (1998) method consisted of DNA extraction from actively growing mycelia (Gardes and Bruns 1993), amplification of the first intergenic spacer region (IGS-1) of the ribosomal RNA using the polymerase chain reaction (PCR), cutting the IGS-1 PCR product with the restriction enzyme ALU 1, and separating the fragments on an agarose gel. Variation in restriction fragment banding patterns characterized the different *Armillaria* species.

Vegetative plate parings were carried out using the methods described by Wu et al. (1996). Each plate was assigned a random number, sealed with Parafilm, placed in clear plastic bags, and stored at room temperature in the dark for 24-28 days. Reactions between isolates were categorized as follows: "0" for complete fusion between mycelia (= same clone), "1" for the formation of a clear gap between mycelia (= different clones of same species), and "2" for formation of a black line of melanized hyphae between mycelia (= different species). At least two plate readers interpreted reactions, and a consensus was reached on plate reactions when interpretations differed.

Clone Identification

We identified clones using the vegetative plate pairing methods described above. First, isolates from within the same infection centers were paired against each other, and if from the same clone one was chosen for further use. Second, isolate(s) representing infection center(s) within the same stand were paired in all combinations. If isolates proved to be from the same clone, one was chosen for further use. Third, the isolate(s) that represented separate stands were paired against each other in all combinations. Finally, 2-3 isolates representing each clone from within the same watershed were paired. A subsample of isolates from each clone identified in 1998 was paired in all combinations against isolates collected in 1999. All 1999 isolates were also paired against each other and the tester isolates.

The number of isolates composing each clone, the maximum width, the size, and approximate age of each clone were determined. Clone width was measured between the two most distant isolates, area was estimated by dot count using the clone boundaries shown in Figure 1, and age was estimated to the nearest 100 years using a growth rate of 2.85 ft/yr (0.87 m/yr) along half of the maximum clone width (Shaw and Roth, 1976).

Results

Field Sampling and Isolations

Armillaria isolates were obtained from six conifer species (Table 1). Isolations from individual trees resulted in 112 *Armillaria* isolates; 87 in 1998 and 25 in 1999. Fifty-four infection centers, representing 21 different stands, yielded isolates in 1998. Isolates collected in 1999 were not tracked by stand.

Species Identification

Two species of *Armillaria* were identified in the 1998 collections. Plate pairing results revealed that four isolates from within one stand were NABS-X, while all 83 others were *A. ostoyae*. The PCR-diagnostic results from both labs matched the plate pairings. Two distinct banding patterns were found that corresponded to these species (Dr. David Rizzo, UC Davis, personal communication). Using the vegetative plate pairing method, all isolates collected in 1999 were identified as *A. ostoyae*.

Table 1. Distribution of isolates by host.

Host	**1998**	**1999**	**Total (%)**
Abies grandis	55	18	73 (65)
Pseudotsuga menziesii	24	3	27 (24)
Pinus ponderosa	4	2	6 (5)
Pinus contorta	3	1	4 (4)
Abies lasiocarpa	1	0	1 (1)
Larix occidentalis	0	1	1 (1)
TOTAL	**87**	**25**	**112**

Clone Identification

Five clones of *A. ostoyae* and one of NABS-X were identified (Figure 1 and Table 2). Two clones of *A. ostoyae*, A and B, extended across watershed boundaries. The four isolates composing the NABS-X clone came from within the same stand, although the full extent of this clone was not documented through further collections. A total of 988 different isolate combinations were needed to complete the vegetative plate pairings.

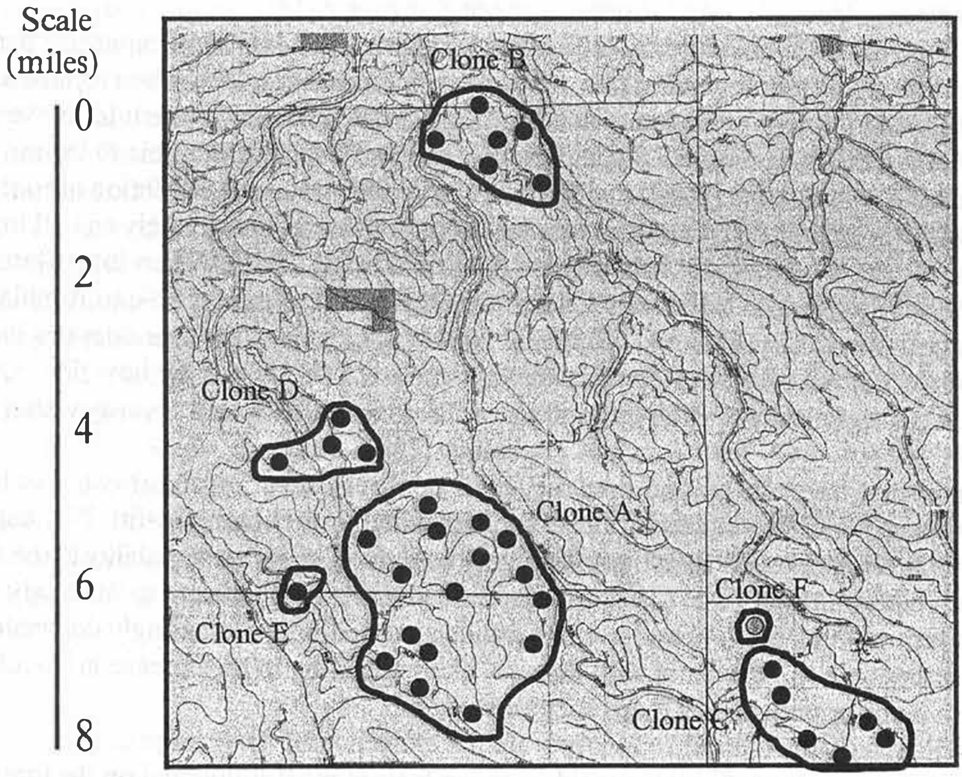

Figure 1. *Armillaria ostoyae* (A-E) and NABS-X (F) clones identified on study area.

Table 2. Clone parameters.

Clone	Species	Isolates	Width (mi) (km)	Area (ac) (ha)	Age (yr)
A	*A. ostoyae*	61	2.6 (4.1)	2800 (1134)	2400
B	*A. ostoyae*	26	1.4 (2.3)	775 (314)	1300
C	*A. ostoyae*	13	1.3 (2.1)	880 (356)	1200
D	*A. ostoyae*	6	1.1 (1.8)	390 (158)	800
E	*A. ostoyae*	2	NA	NA	NA
F	*NABS-X*	4	NA	NA	NA

Discussion

Our findings have confirmed the existence of massive clones of *Armillaria ostoyae* in dry, coniferous forests (Adams 1974; Shaw and Roth 1976; Anderson et al., 1979). We have documented the largest known clone of *A. ostoyae*, and perhaps of any soil-inhabiting fungus. Brasier's comments (1992) regarding the remarkable genetic stability of a clone of *A. bulbosa* in Michigan are even more pertinent. Clone A is 6.5 times the maximum width of the Michigan *A. bulbosa* clone, yet mycelia from Clone A isolates separated by 2.6 mi (4.1 km) merged as readily as those from adjacent trees.

Considering the estimated age of 2400 years for Clone A, it has been expanding across this area for perhaps 8-10 forest generations. This likely included episodes when recurrent ground fires produced homogenous, open stands of ponderosa pine and western larch over large portions of the study area. Lower density stands are considered less susceptible to the rapid spread of Armillaria root disease (Shaw and Roth, 1976) due to reduced likelihood of root-to-root contact, while ponderosa pine and western larch are considered moderately and seldom damaged, respectively, by Armillaria root disease (Hadfield et al., 1986). Therefore, Clone A most likely attained its current size in stands we would consider less susceptible to Armillaria root disease in both forest structure and composition. If so, what implications does this have for our understanding of how *A. ostoyae* spreads through natural forests, and for how fire suppression and management activities can influence disease incidence and severity within the current forest?

Low-intensity, frequent ground fires may have no direct effect on *A. ostoyae*, but instead remove highly susceptible, fire-intolerant hosts such as grand fir and Douglas-fir. Filip and Yang-Erve (1997) demonstrated that low-intensity fires reduce *A. ostoyae* viability at the 6 inch (15.2 cm) depth but not at the 12 in (30.5 cm) depth in a watershed adjacent to our study area. In the absence of ground fires these mixed-conifer stands are becoming increasingly dominated by species more susceptible to Armillaria root disease, likely resulting in an increase in inoculum potential within clone boundaries as these species succumb.

Forest planning efforts need to incorporate the existence of these large clones. Landscape-level planning by definition considers those factors most influential on the forest landscape. Within our study area roughly 5000 ac (2025 ha) out of 64 sq mi (166 sq km), or 12% of the total area, falls within the boundaries of known Armillaria root disease clones, although far from all is in active mortality centers. How and when should we incorporate this amount of root disease into forest planning? At the stand level, can the Western Root Disease Model accurately predict the behavior of the patchy mortality occurring within the boundaries of these large, contiguous clones, and does modeling individual mortality centers within these much larger clones make sense?

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Approaches to Investigating Pinyon Mortality in Southwest Colorado

Samuel F. Harrison and William B. Jacobi, Colorado State University, Fort Collins CO

A study was begun in 1997 in order to examine patterns of mortality of pinyon pine (*Pinus edulis*) due to various agents, most notably black stain root disease (*Leptographium wageneri*), Ips bark beetles (*Ips sp.*) and human perturbation of the environment by means of road building, home construction, and recreational use. This study was undertaken using both conventional forest sampling techniques, and also remote sensing techniques, including aerial photography and geographic information systems (GIS). Mortality was sampled for two areas in southwest Colorado, totaling approximately 115 square miles in size. Along each of 50 transects, all pinyon mortality was recorded, and periodic plots were established to record the characteristics of both live and killed trees, as well as other underlying site characteristics such as topography, vegetative cover, and sources of anthropogenic disturbance. Analysis of the data suggests that incidence of mortality is highest in pinyon stands characterized by high densities of small diameter trees with below average amounts of non-pinyon vegetative cover. Relationships between mortality and topography were inconclusive, as were relationships between mortality and site disturbance by humans. At the same time, infrared aerial photography at the 1:6000 scale was obtained for both areas. These photographs were manually interpreted to detect all recognizable pinyon mortality on the landscape. Interpreted images are being converted to GIS coverages for the purpose of spatial autocorrelation analysis between pinyon mortality and underlying site factors such as slope, aspect, elevation, soil type, vegetative cover, and land use. When completed, the study will provide a model for pinyon mortality in the region, as well as a much-needed comparison of the accuracy and utility of technology-based sampling and analysis, as opposed to conventional sampling, of patterns of forest disease.

A Douglas-fir Beetle Outbreak on the Idaho Panhandle National Forests

By Sandra Kegley and Carol Randall, USDA Forest Service, Coeur d'Alene, Idaho

An ice storm and a series of heavy snow and wind events during the winter of 1996-1997 triggered the largest Douglas-fir beetle, *Dendroctonus pseudotsugae,* outbreak on the Idaho Panhandle National Forests since the early 1950's. After a population increase in the downed and broken trees, hundreds of thousands of green trees were attacked by the beetles in the spring of 1998. The magnitude of the Douglas-fir beetle outbreak is due to the large triggering event and, to some extent, forest conditions. A major species shift has occurred from a high proportion of pines and larch in the early 1900's to a predominance of Douglas-fir, grand fir, and western hemlock today. The introduced disease, white pine blister rust, early logging activities, and fire suppression have contributed to the change in forest composition. The result is forests more succeptible to many of our native diseases and certain insects leading to a decline in overall forest health. Heavy sporulation of the sap rotting fungus *Cryptoporus volvatus* was observed on infested trees by the fall of 1998. Up to 32% volume loss from sapwood decay and incipient brown cubical rot occurred in some trees one year after beetle attack.

The Idaho Panhandle National Forests responded to the beetle outbreak by completing an Environmental Impact Statement addressing 25,000 acres of the hardest hit areas on the forest. An extensive public information campaign was conducted and logging and restoration activities are now proceeding after a favorable court decision on a lawsuit filed by environmental groups.

We had the opportunity to conduct several pheromone studies during 1999. The Douglas-fir beetle anti-aggregation pheromone (MCH) was used to protect trees on large acreages and tested on very small acreages and individual trees. Attractant pheromones were used in traps in a test to manipulate the pattern of beetle caused tree mortality across a landscape. Different pheromone strengths and trap placement designs were also tested. Results of these pheromone studies are currently being analyzed.

Swiss Needle Cast Assessments in Washington and Oregon Coastal Douglas-fir plantations

Will Littke and John Browning, Forest Pathologists, Western Forestry Research Center, Weyerhaeuser Company, Centralia, WA.

Coastal Swiss Needle Cast Conditions on Company Lands in WA and OR

Swiss needle cast (SNC) of Douglas-fir, caused by *Phaeocryptopus gaeumannii*, is currently at heightened levels throughout Washington and Oregon. This disease is native to Pacific Northwest forests. The life cycle of SNC has been extensively published (Hood 1982, Chastagner and Byther 1983, Michaels and Chastagner 1984). SNC infection of Douglas-fir takes place principally during needle elongation in the spring (Chastagner 1982). During the growing season, the fungus grows in and colonizes the needle. Fruiting bodies (pseudothecia) of the fungus begin to appear by fall and are fully developed by the following spring. The fruiting bodies can be found on the undersurface of the needle and appear as *small black specks* within the stomatal openings. As SNC disease develops, more and more of the stomatal surface becomes plugged. Eventually the fungus causes the premature loss of the needle, however the exact cause of this needle loss is uncertain. SNC infection levels have been quantified by estimating tree foliage retention levels and by counting the number of stomata openings plugged by the fungus on foliage of any age class.

Each spring, surveys are conducted on Company lands along the Washington and Oregon Coast to gauge and track SNC conditions. It is important to conduct this survey in the spring, prior to bud flush, at a time when disease symptoms are most prominent. Foliage color and estimates of needle defoliation are used as indicator symptoms of stand disease levels. Stand SNC impact is visually estimated using the following criteria: *low level impact* (normal foliage color with at least 3+-years of foliage retention); *moderate level* (foliage light green-chlorotic but retaining ± 2-years of foliage); and *heavy impact* (tree color bright yellow with thinning or bare crowns and less than 1 year of foliage remaining). Most stands within the survey area have been viewed and rated for three or more years.

In our 1998 spring survey, we observed those non-Company lands on the Willapa River valley floor and stands south of South Bend met the visual criteria for moderate-heavy impact. Many of these valley floor and coastal Douglas-fir stands are situated in fog bound areas, which increase the infection potential of the disease (Hood 1982). Low elevation DF stands (mostly current or old Christmas tree farms) along the Willipa often occur on wet soils with restricted drainages. Such topgraphic sites have been reported to have a high risk for SNC. On the other hand, stands situated further from the coast or on topography with better air drainage were judged to have low to low-moderate impact from SNC infection.

We rated stand SNC disease levels along the same Washington State coastal transect during the spring of 1999. Stand disease levels were slightly higher here than rated in the 1998 survey. Like the 1998 survey, stands along the Willapa Valley floor, Raymond, South Bend show more defoliation.

Douglas-fir stands situated near Seal's Slough (Willipa Bay) appeared very chlorotic (yellow) with some individuals trees lacking nearly all of their upper 1-year old needles. . This type of defoliation is often cited as being caused by SNC, but needle infection data does not support that SNC alone is involved. Stands situated further from the coast were judged relatively unchanged from the 1998 survey, with low- to moderate low levels of disease in areas surrounding the towns of Pe Ell, Montesano, Smith Creek, and the Independence Valley.

Environmental conditions might also influence the level of SNC. During 1998 a late summer drought occurred where no rain fell for over 50 days, and during the winter several severe high winds events occurred. These events might also have compounded the apparent increase in disease levels along the coast this last winter.

Swiss Needle Cast Assessments- Washington Wide Adaptability Genetic Test Sites

Douglas-fir stands in the *coastal hemlock-spruce zone* of are thought to have higher disease potential for SNC than stands situated further from the coast *(such as the adjacent dry-hemlock zone*). Stand disease observations from 1997 to 1999 suggest that some coastal regions have undergone a gradual increase in apparent SNC disease over the past several years. Weyerhaeuser Company installed and has maintained replicate 13-year old Douglas-fir genetic test sites situated within and adjacent to the coastal zone (and 6-other tree growing zones). These sties were evaluated to determine the impact SNC disease on the growth of Douglas-fir.

Replicate full-sib genetic test sites established at Raymond (*coastal hemlock-spruce zone*) and Doty, (*dry-hemlock zone*) Washington was selected to develop a SNC disease quantitative protocol. Project goals included the development of a series of visual foliar assessment protocols from which to relate SNC disease level to tree growth parameters. To accomplish this, SNC disease levels and foliar retention on Douglas-fir were quantified across a representative sample taken from 13-year old Douglas-fir originating from Vail, Longview, Cascade and Twin Harbors seed sources. Comparisons were made between genetically improved families and non-improved seed sources.

Methods of Assessing SNC

SNC disease assessments were made on ten 13-year old trees sampled at random from individuals representative of each seed source zone. Branches were sampled from the upper 3rd and 5th whorls with a total full crown length down to the 7th whorl. Lateral branches were subsampled in March for needles representing 1-year old (1997) and 2-year old needles (1996). Twenty needles per age class and sample tree were selected at random and placed stomatal side up on white 3X5-inch cards using double sided tape. Estimates of the percent of stomatal plugging were made under 100X magnification and by counting 1-random field of view of stomata (roughly 200 stomata) per needle. Sample points on each needle were picked at random from the petiole end of each needle. The percent of needle surface plugged for each tree and each foliage year were calculated by averaging these 20 random assessment points. Stomatal plugging by pseudothecia or by pseudothecial remnants was counted as a positive. The degree of stomtal plugging is viewed as a quantifiable indication of how fast the fungus is reproducing on a tree-higher psuedothecial counts being indicative of a less disease tolerant trees.

In addition to stomatal plugging estimates, foliar retention values were made on replicate branches from each crown sample position. Foliage retention was estimated to the nearest percent for 1-year, 2-year, and 3-year old branchlets in the upper 3rd and 5th whorl branches.

Results

The Raymond genetic test site is situated within 10 miles of the coast. Spring moisture conditions and spore production by the SNC fungus are thought not to be limiting to infection at this site. However, most trees at Raymond show rather low levels of stomatal plugging by SNC in 1-year old foliage (Figure 1a). SNC disease levels on 2-year old needles do increase as the fungus continues to produce fruiting bodies (Figure 1b).

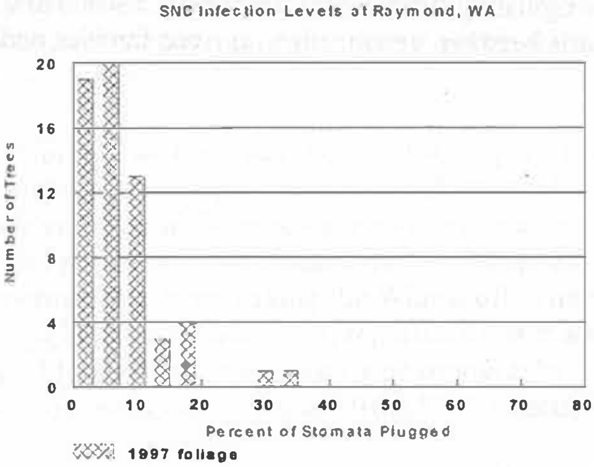

Figure 1a.. The percent of stomatal area plugged by the fungus on individual trees after the first year's growth. Samples taken in spring 1998 from 1997 foliage age class at Raymond Genetic Test site.

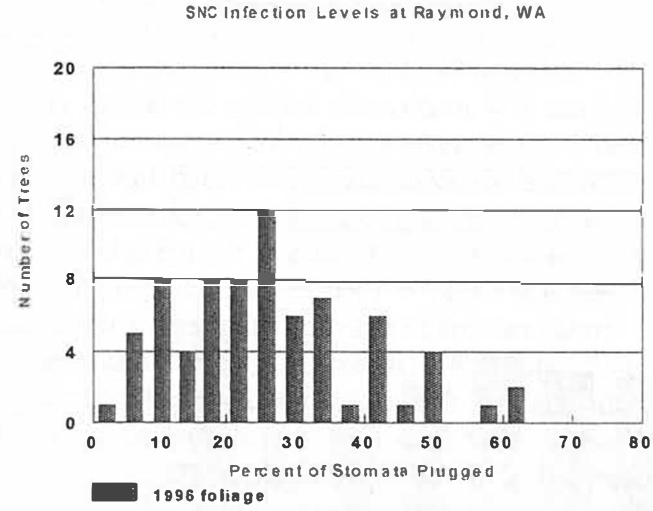

Figure 1b.. The percent of stomatal area plugged by the fungus on individual trees after the two years. Samples taken in spring 1998 from 1996 foliage age class at Raymond Genetic Test site.

Douglas-fir seed sources from genetically improved versus non-improved sources were analyzed using the 2-year old needle SNC disease development data. Analysis found no statistical significance between Douglas-fir sources (parents originating from Cascade, Vail, Longview or Twin Harbors sources) (Figure 2). There was also no significant difference between improved and checks within a source

SNC disease levels on 2-year old foliage at Doty , Washington (dry hemlock zone) were considerably lower than those reported from Raymond. Average percent stomatal plugging on 2-year old foliage at Doty was 14% as compared to 25% at Raymond. There was no significant difference by source or for genetically improved versus non-improved.

SNC disease levels (Raymond and Doty) were found to be poorly correlated (r^2=0.2) when percent stomata plugged and foliar retention values were tested against tree height growth and DBH. The low correlation observed between SNC and growth is likely because of the higher mean foliar retention values in our study than those reported for Tillamook (Maguire 1998 OSU-SNC COOP)(see Figure 3). Mean foliar retention values of ± 2.5-3-years at Raymond and Doty translate to only a minimal impact (<±3%), if any, on growth. This would indicate that at current SNC needle infection levels at Raymond and Doty is having little impact on DF growth.

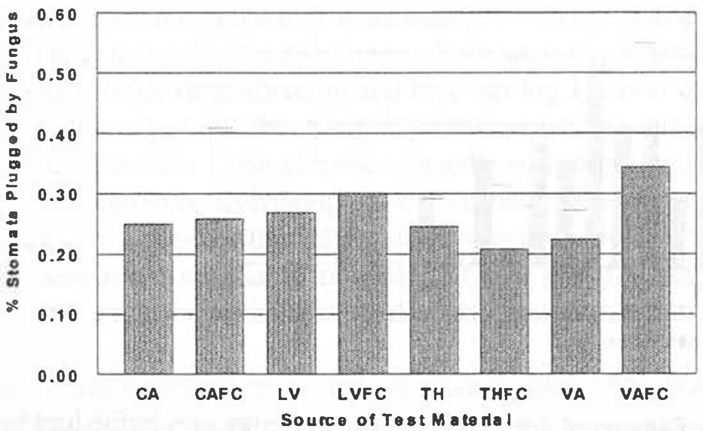

Figure 2. Average SNC needle infection (error bar shows 95% confidence interval) expressed as percent of stomata plugged on 2-year old needles for 13-year old Douglas-fir genetic select and non-improved trees (Field Check) grown at *Raymond, Washington.* Trees were sampled at the fifth-whorl from the top. Sources represented: CA (Cascade); CAFC (Cascade Field Check); LV (Longview); LVFC (Longview Field Check); TH (Twin Harbors); THFC (Twin Harbors Field Check); VA (Vail); and VAFC (Vail Field Check).

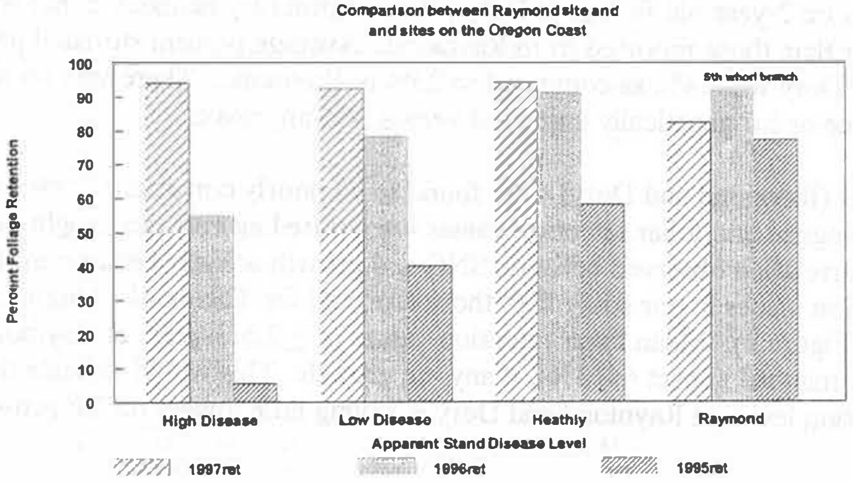

Figure 3. Levels of foliar retention between various disease impact sites in Oregon and at the Raymond, WA genetic test site.

Current and New Research Areas:

Severe stand color and defoliation conditions in WA and OR coastal stands developed suddenly after high windstorms during the winter of 1998 and early 1999. We quantified levels of SNC in early 1999 along coastal and interior transects of WA and OR and concluded that this defoliation was not correlated to current SNC disease levels alone. These observations point to possible foliage interactions with direct mechanical forces or indirect interactions with sea-salt deposition. The European literature suggests that Douglas-fir is one of the least tolerant conifers to direct marine exposure and is not salt tolerant. Research in Oregon (Bockheim and Langely-Turnbaugh 1997) and Washington (Edmonds et al 1995) show that marine terraces in these immediate coastal regions receive significant amounts of sodium chloride as a consequence of winter storms. Bockheim and Langely-Turnbaugh (1997) suggests that sodium chloride dominates the soil chemistry profiles for periods of the growth year and adversely influence tree nutrient uptake of important cations and anions. We have undertaken research to actively investigating the possible interaction of SNC and salt in coastal stands as a possible explanation for the seemingly difference in stand disease symptom development.

SNC Conclusions

The last documented Swiss needle cast epidemic occurred in western Washington and Oregon during1979-1987. Much of what we know about this fungus and its host and control was learned during that episodic event. It should be no surprise then, that SNC would again make a re-appearance as weather and stand conditions favorable to the disease return. The very severe disease conditions apparent at Tillamook along the Oregon Coast appear to be limited to a few similar coastal areas Certainly, SNC levels in these severely impacted coastal sites require additional research to fully understand the entire disease complex. . However, current stand SNC conditions elsewhere in Washington and Oregon Douglas-fir forests do not indicate a spread of these severe defoliation levels even after 6 years (1993-1999).

Monitoring of SNC disease development (aerial and ground based surveys) in all DF stands are needed to keep abreast of disease conditions in WA and OR. A standardized method for quantifying SNC disease level on individual trees is also needed. The relative tolerance of genetic sources to SNC needs to be determined to provide disease risk information to effectively manage coastal and other environments where SNC might be present.

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Potential Wildlife Significance of Mortality Centers Detected by Remote Sensing in the Longview Washington Forestry Region

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BACKGROUND/PURPOSE: Northwest Aerial Reconnaissance (NAR), Bremerton, Washington has developed and demonstrated a aerial photographic methodology to detect and map the occurrence and distribution of standing tree mortality (caused by *Phellinus weirii*) in Douglas-fir stands. The methodology is best suited for harvest age stands, but could also be effective at detecting mortality in plantations as young as 15 years. Map data is compatible with most current information mapping GIS technology. In July of 1998, NAR photographed approximately 2500 acres in the Silver Lake and Yacolt forestry units within the Longview, Washington management region. Later, ground-transect surveys revealed that 67-72% of the detected mortality was caused by root disease fungi (principally, *Phellinus weirii* and *Armilaria Ostoyae*). Accuracy of standing mortality detection approached 80-100%. The method can not detect mortality occurring obscured by the forest canopy.

In 1999, we proposed a follow-up survey to evaluate the wildlife significance of this technology. This project was conduct as part of a Summer Intern Position TOSA (Teacher on Summer Assignment).

OBJECTIVE: Use Northwest Aerial Reconnaissance (NAR) based mortality data from Silver Lake and Yacolt for snag/wildlife surveys to:

(1) Quantify vegetation in mortality gap areas occurring in 22-35 year old and >35- year old DF stands.
(2) Determine the number of snags and windthrow trees associated with specific mortality agents and various sized gaps.
(3) Quantify snag characteristics and wildlife use
(4) Develop recommendations based on these study results on the use of this technology in other landscape applications.

METHODS:

Study Areas: NAR uses a standard color aerial photograph taken from 12,000 ft with a longer focal length lens. Photos taken in mid to late summer (July) capture the best distinction between healthy and dead trees. Dead trees must be co-dominants or dominants in a stand or on the edge of stands to be detected by their analysis program. Dead tree (-s) are designated on the map as a 60-foot diameter circle so as to make area impact assessment possible. Each photo-"hit" is given a unique GIS number and is displayed on color maps. Stands less than 20 years of age were not considered in this portion of the study.

The Silver Lake study site lies roughly 1 mile due south of Silver Lake, east of Castle Rock, Washington. Total acreage of the study area is 1380 acres, roughly divided into the following age classes: 13-24 years, 80 acres; 25-39 years, 316 acres; 42-69 years, 957 acres; >70 years, 27 acres. Stands at Silver Lake are stocked mostly with Douglas Fir, with some intermixed hardwoods, primarily red alder and bigleaf maple. In the 1998 survey, root disease accounted for 67% of the mortality detected, with 17% due to animal damage, and 16% from other causes.

The Yacolt study site is south and east of Silver Lake, and north east of Tumtum Mountain near Amboy, Washington. Total acreage of the study area is 1063 acres, roughly divided into the following age classes: 13-24 years, 55 acres; 25-39 years, 759 acres; 42-69 years, 232 acres; >70 years, 17 acres. The stands at Yacolt are roughly divided between Douglas Fir and Western Hemlock. Hardwoods are also present, mostly alder and bigleaf maple. In the 1998 survey, root disease accounted for 72% of the mortality detected, with 23% due to animal damage, and 5% from other causes.

Stand Selection Criteria: Stands were divided into two age class groups corresponding to 22-35 year old and 36+ year old stands. This portion of the project focused on 14 separate stands from which 35 discrete mortality centers had been previously mapped. In each stand we used mortality centers as individual plots.

Mortality/Wildlife Assessment Methods: Each discrete mortality center was first identified on the photo and then on the ground. Each center was evaluated for the following criteria: **mortality center size, total number of snags, snag condition classification, snag size, number of windthrow trees, wildlife activity, and understory vegetation**. For the purpose of this discussion, the terms **center, gap, and mortality center** are used synonymously. For the purpose of these proceedings, exact details of the measurement criteria have been greatly abbreviated.

RESULTS

Disease Center Characteristics: Remote-sensing methodology in these stands is able to locate visible standing mortality centers with an accuracy of 95% (Littke and Browning unpublished results). Mortality centers must have at least a codominant height structure. Shorter dead trees not visible from the air can not be detected, but can be found through more intensive survey methods such as ground based surveys. The cause of mortality in either case must be validated using ground surveys.

In the current study, mortality gaps ranged in size from 314 sqft (.0072 acres) to over 9801 sqft (0.23 acres). Figure 1 shows the number of snags present in gaps of varying size.

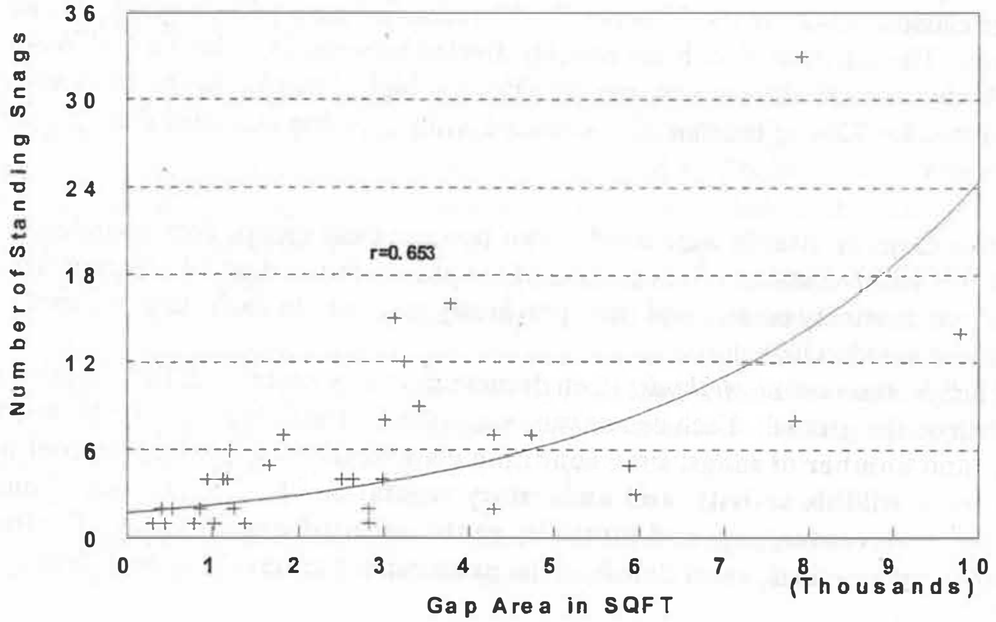

Figure 1. Relationship of the number of standing snags as a function of gap size

Mortality gaps created by root-rot fungi (Phellinus and Armillaria) were more common (n= 27/35 centers) than those created by other gap agents (bears 4/35, bark beetles 2/35, other 2/29) respectively. The sample data supports our 1998 validation survey showing 67% of visible mortality at Silver Lake and 72% of mortality at Yacolt was caused by root rot fungi.

Thomas and Halpern (1998) found gaps in otherwise well stocked conifer stands prolong or perpetuate the early successional stage vegetation species. We suggest that mortality gaps >3,000 sqft might be separated from smaller gaps, since they provide both a greater number of understory species, while producing effective fruit and berry production. Although, similar under story plants species are present in small gaps, there is insufficient light to make the plants productive (Figure 2).

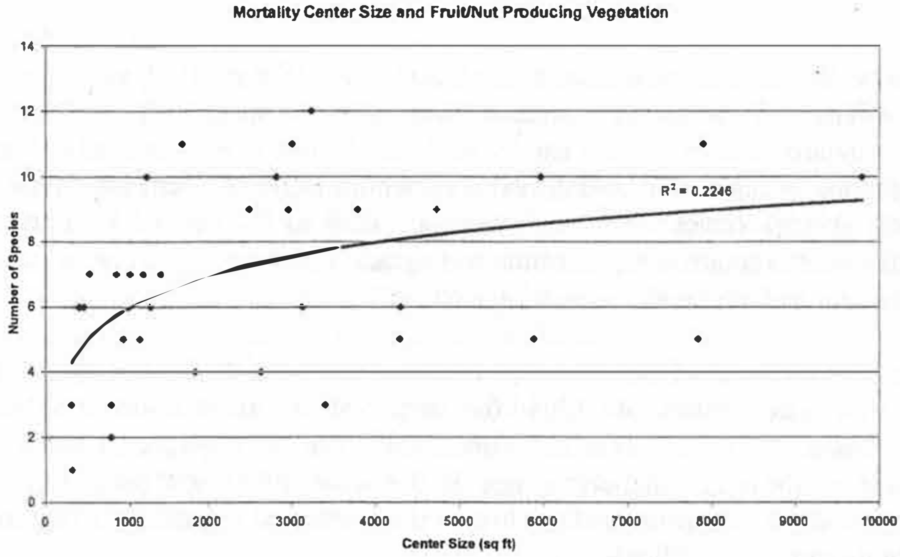

Figure 2. Relationship between center size and edible berry and nut species present.

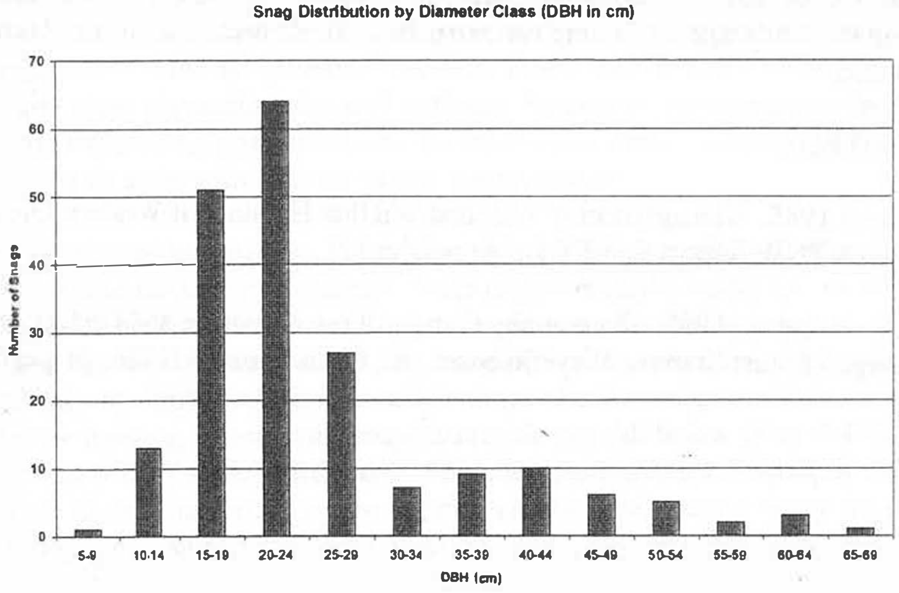

Figure 3. Total number of snags examined in 35 gap centers by dbh diameter class.

Wildlife Use of Snags: Wildlife use was examined on 200 snags (Figure 3). Over 50% of snags did not show any evidence of wildlife use, because many of these snags were too small or too newly formed to fit standard models of snag use by wildlife. Brown (1985) lists habitat structure of various snag inhabiting species. He established a minimum DBH of 28cm for cavity nesting birds, but other birds species (chickadees) use snags as small as 23 cm DBH. Furthermore, decay organisms and insects require adequate time to degrade the wood structure to make these snags attractive as feeding and eventually as nesting sites.

> We found evidence that 63 out of the 200 snags had been used as feeding sites by woodpeckers or other bird species. We found five snags with a total of seven cavity nests in current or recent usage. Six of the seven nests occurred in the older age class stands indicating a preference for larger diameter snags. In this study, all of these snags were created by root disease. In addition, we found several unidentified ground nests on root-wads created by Phellinus caused windthrow

CONCLUSIONS: Low level aerial photography coupled with computer enhanced photo interpretation provides a reliable and economically method to map visible mortality centers and snags. It allows center size to be determined with an accuracy adequate to distinguish larger gaps (> 3,000 sqft) with more suitable habitat structure for wildlife, from smaller mortality gaps.

Once mapped, mortality centers can indicate areas rich in snags and under-story vegetation diversity. Mortality gaps that meet criteria for snag size and number can be quickly identified and may be left on the landscape as wildlife reserve areas. These areas may be preferentially sampled for nest sites.

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Spruce Aphid in the Southwestern Mountains

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Spruce aphid (*Elatobium abietinum* (Walker)) (Homoptera: Aphididae) is an exotic organism causing extensive damage on Engelmann spruce (*Picea engelmannii*) and Colorado blue spruce *P. pungens*) in Arizona and New Mexico. Spruce aphid was first reported in the Southwest in late 1988 in the White Mountains (USDA Forest Service 1997a), where approximately 40 ha were defoliated, as were ornamental spruce in the Santa Fe, New Mexico metropolitan area. Epizootics have occurred during the autumn (and possibly the following early winter or spring) of 1988, 1989, 1995, 1996, and 1999. The 1989-1990 outbreak possibly affected 40,000 ha. The 1995-1996 outbreak defoliated only 11,300 ha, but was more severe. Ground-based reconnaissance since 1996 detected defoliation in the Mogollon Mountains and Sacramento Mountains in New Mexico. More recently, spruce aphid and approximately 15 ha of associated defoliation was discovered in the Pinaleño Mountains. The Pinaleño infestation is almost certainly fairly recent, as recent weather in that mountain range has been warmer than in the White Mountains and Sacramentos, and an aphid population shouldhave manifested an epizootic event once it was present. In any case, wildland aphid populations have expanded in the Southwest from 40 ha in one mountain range in 1988 to over 11,000 ha in four mountain ranges eleven years later. During the autumns and early winters of those eleven years, there have been five defoliation episodes in wildland forests..

Spruce aphid is previously known from coastal areas of Europe, Chile, Iceland, New Zealand, the Falkland Islands, and northwestern North America, primarily on Sitka spruce (*P. sitchensis* (Bong.) Carr)., white spruce (*P. glauca* (Moench) Voss), and Norway spruce (*P. abies* (L.) Karst). In those areas population size and outbreak frequency are determined by the size of the previous season's suriviving population and the severity of winter weather, so that epizootic events are limited to areas with mild maritime winter climate.

The Southwest situation is alarming, in that the environmental conditions, specifically cold temperatures, exceed the known biological limits underwhich the insect has incurred epizootics elsewhere. In maritime European areas, aphids begin to starve during extended periods below 6°C, the coldest known field survival is -23°C, and 60% of aphids die after 2 hours at -12°C. In Europe, outbreaks are limited to periods or locations where average monthly mean temperatures do not fall below freezing, or ambient temperatures do not fall below -8 to -14°C, with similar patterns observed in the Pacific Northwest. These temperatures are frequently exceeded in high elevation forests in the Southwest, where the mean annual and mean January temperatures within the range of Engelmann spruce are 2 and -9 to -7°C, respectively

There seem to be other differences in aphid biology and population dynamics between the Southwestern mountains and other areas where this insect is a problem. The local host species in Arizona and New Mexico are Engelmann spruce and Colorado blue spruce; in coastal areas the host species are primarily Sitka spruce and white spruce (the host species are exotic in problem areas in Europe). Engelmann spruce is one of the most cold-tolerant *Picea* species, while Sitka spruce is one of the least. Several needle cohorts are attacked and defoliated in North America, where in Europe only the most recently produced age class is attacked. Population increases and defoliation normally occur in the spring in maritime areas, with rare outbreaks in the fall or early winter. Outbreaks in the Southwest occur in the autumn and early winter.

Dynamics of Pheromone Production and Communication in the Mountain Pine Beetle, *Dendroctonus ponderosae* Hopkins and the Pine Engraver, *Ips pini* (Say)

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The mountain pine beetle, *Dendroctonus ponderosae* Hopkins and the pine engraver, *Ips pini* (Say), often co-exist in lodgepole pine, *Pinus contorta* var. *latifolia* Engelmann. Intra- and interspecific semiochemical communication occurs in both species and their complete semiochemical repertoire and precise dynamics of pheromone production have not been elucidated. Porapak-Q extracts of captured volatiles from beetles of both species aerated at different attack phases (freshly emerged, pioneer sex alone in the log and both sexes paired in new galleries), followed by gas chromatographic-electroantennographic detection (GC-EAD) and GC-mass spectroscopic analyses identified 17 compounds that excited the antennae of either or both species. Seven compounds for *D. ponderosae* and nine for *I. pini* had not been assessed for behavioural activity. In field trapping experiments, 2-phenyl ethanol produced by both species inhibited the response of *D. ponderosae* to its aggregation pheromones. *exo*- and *endo*-Brevicomin produced by *D. ponderosae* significantly decreased the response of *I. pini* to its aggregation pheromone ipsdienol. Nonanal, a ubiquitous compound found in the volatiles of lodgepole pine, various nonhosts and in both beetle species deterred the response of *I. pini* to ipsdienol. The occurrence of *cis*-verbenol, *trans*-verbenol and verbenone in emergent *I. pini*, and verbenone and 2-phenyl ethanol in *D. ponderosae* suggests that these compounds may prevent aggregation and induce dispersal following emergence. Termination of aggregation in *D. ponderosae* appears to depend on the production of frontalin in combination with changes in the relative ratios of verbenone, *exo*-brevicomin, *trans*-verbenol and 2-phenyl ethanol. In *I. pini*, the rapid cessation of ipsdienol production by males is probably the main factor in terminating aggregation.

Influence of Host Condition on the Red Pine-*Sphaeropsis sapinea* Interaction in Wisconsin Plantations.

Stanosz, G. R., and Blodgett, J. T. University of Wisconsin, Madison, WI

Some of the most frequent and severe damage caused by *Sphaeropsis sapinea* (syn. *Diplodia pinea*) in North America has occurred in Wisconsin on red pine (*Pinus resinosa*) during the last 25 years. The influence of host condition, specifically stress associated with drought, on development of disease caused by *S. sapinea* has been examined in a series of studies (1, 2). The aggressiveness of *S. sapinea* isolates was compared on water-stressed and nonstressed red pine seedlings in greenhouse and growth chamber experiments and on established red pine trees in a 3-year plantation study. Predawn water potentials (ψ_{PD}) were manipulated by withholding water (greenhouse/growth chamber), and by removing competing vegetation and supplemental watering (plantation). In both situations, young shoots were wounded and then inoculated. The pathogen caused more severe symptoms and could be reisolated farther from the site of inoculation of water-stressed trees than nonstressed trees, in all experiments. In the plantation, the most severe disease development occurred in the driest year, and disease was least severe in the wettest year. Competing vegetation enhanced disease development by inducing water stress, even in the wettest year, even on these trees that were considered well established.

Damage associated with *S. sapinea*, in the absence of the more traditionally observed shoot blight symptoms, also has been investigated (3). Recently planted seedlings and established saplings frequently died during 1992 and 1991, respectively, in red pine plantations in Wisconsin. These epidemics appeared to be related to substantial rainfall deficits in each year, compared to 30-yr averages. Mortality of seedlings in 12 plantations ranged from 14 to 95%. Mortality of saplings in 16 plantations ranged from 0 to 30%. Symptoms included blackened cortical tissue and dark staining of the underlying xylem in the lower stems and root collars. Pycnidia of *S. sapinea* were observed in these areas on 17 to 97% of dead seedlings. Pycnidia of the pathogen were observed on the lower stems or root collars of 67 to 87% of dead saplings examined in four plantations. These observations comprise the first association of Sphaeropsis collar rot with high frequencies of red pine mortality in either established saplings or recently planted seedlings.

The role of water stress in the initiation of collar rot by *S. sapinea* in latently colonized red pine seedlings was investigated in two greenhouse experiments (unpublished data). Seedlings were not inoculated, but had been obtained from nurseries where the pathogen was present and where asymptomatic persistence previously has been demonstrated (4). In experiment 1, seedlings were either watered to maintain mean predawn needle water potential (ψ_{PD}) of -0.55 MPa, or not watered until mean $_{PD}$ of -1.1, -1.7, -2.0, -2.5, or -3.2 MPa were achieved. Seedlings developed symptoms, including mortality, resembling those of Sphaeropsis collar rot. Mortality ranged from 7.5% of repeatedly watered seedlings to 50% of those in the driest regime ($P < 0.001$). The pathogen was identified from 42% of the living seedlings and 92% of the dead seedlings, with the most frequent identification overall (for seedlings living or dead) in the driest regime (72%). In experiment 2, seedlings were either watered to maintain mean $_{PD}$ of -0.65 MPa, or not watered until mean $_{PD}$ of -2.8 MPa was achieved. Half of the seedlings in each watering regime also were treated with benomyl. Mortality was low ($\leq 4\%$) for watered seedlings, whether or not fungicide was applied. Mortality of nonwatered seedlings, however, was greater among nontreated seedlings (61%) compared to benomyl-treated seedlings (37%) ($P < 0.001$). Results support the conclusion that physiological alteration can effect release from the quiescent condition to result in rapid disease development and confirm that *S. sapinea* can act as a latent pathogen. The ability of *S. sapinea* to persist on or in the asymptomatic host and its responsiveness to host condition help explain the repeated, sudden, and increasingly widespread episodes of disease experienced in Wisconsin.

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The Semiochemistry of the White Pine Weevil

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The white pine weevil, *Pissodes strobi* Peck, destroys the terminal leaders of young spruce and pine in North America. The chemical ecology of *P. strobi* in British Columbia will be investigated to determine an attractive pheromone and kairomone bait. *P. strobi* produce and detect grandisol and grandisal, the aggregation or sex pheromone used by other *Pissodes* weevils, but have not exhibited a behavioural response to the pheromone. Gas chromatographic-electroantennographic detection (GC-EAD) will be used to determine semiochemical differences between *P. strobi* and a sibling species, *P. schwarzi*. Olfactometer bioassays and field trials will be used to test both pheromone and host tree volatiles. Non-host tree volatiles will be tested as potential deterrents on high value trees. This research will lead to semiochemical monitoring, mass trapping and tree protection as components of an integrated pest management strategy for the white pine weevil.

Invasive Forest Pests: International Problems Associated with Solid-Wood Packing Material

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Non-native invasive pests cause forest composition changes that reduce biological diversity as well as the economic value of forest ecosystems (Wallner 1996). The rate of establishment of foreign organisms in the United States has increased over time due to economic, political, and technological factors (Office of Technology Assessment 1993). More than 4,500 nonindigenous organisms have established in the United States, including 400 insect and 20 pathogen species that attack trees and shrubs (Mattson et al. 1994). Nonindigenous insects constitute approximately 2 percent of the U.S. insect fauna. More than 27 percent of these major forest pests have been introduced (Pimentel 1986). Three quarters of the invasive insects and half of the invasive tree pathogens are of European origin. The balance is from Asia. Historically, there has been a "trade imbalance" in the exchange of nonindigenous forest insects—North America has received more than 10 times the number of pests from Eurasia than vice versa (Niemela and Mattson 1996). The reasons for this are not clear, though pest competitiveness and extent of composition of North American forests are believed to be important factors.

Pathways for introducing pests include, but are not limited to, natural spread, entrepreneurship, and product, germplasm, and vehicular transportation. Certainly, the rapidity by which material is moved around the world ensures safe passage and survival for many organisms, and is reflected in invasive pest establishment and in the known first detected establishment of insects of woody vegetation in North America (Fig. 1). The northeastern and northwestern regions have been the recipients of a majority of pest insects and diseases (Mattson et al. 1994). Although there have been introductions elsewhere, the active nature of commercial ports in these regions, along with their climate and proximity to a broad range of hosts have made them centers for bioinvasions. As with most urban settings, their ecosystems have been disturbed and simplified. However, plantings of exotic plants there, many of which are genetically similar to those found in an invasive pest's native country, increase the probability of establishment.

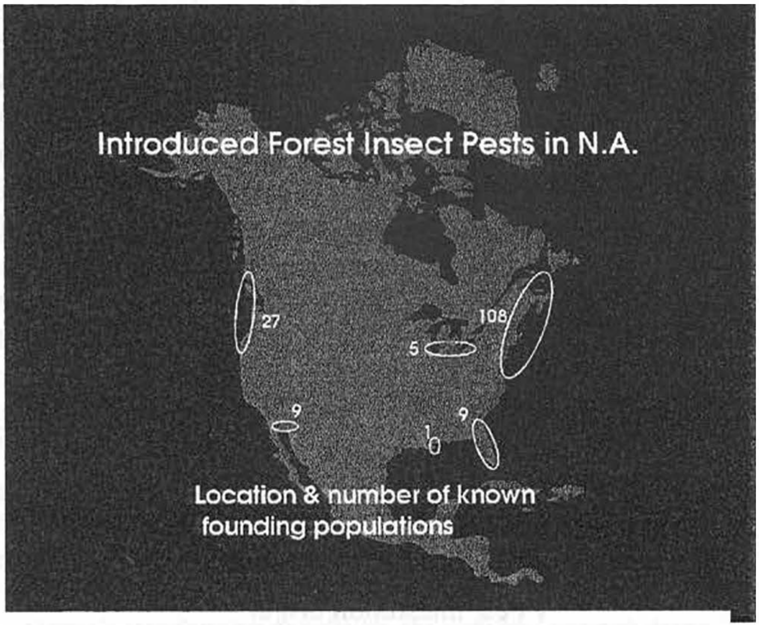
Introduced Forest Insect Pests in N.A.
27
108
5
9
9
1
Location & number of known founding populations

Figure 1. Location and number of known founding populations of introduced forest insect pests in North America.

Voluminous international trade in a wide variety of products has increased invasions of forest pests and complicated detection, and the recent emergence of China as a major trading partner of the United States has escalated the probability that new pests and unique pathways will be introduced. Traditional introduction pathways for forest pests, e.g., logs, nursery stock, wood chips, germplasm, can be estimated by risk analyses. Such analyses have alerted regulators of impending risks from the importation of larch from Siberia (U.S. Dep. Agric. 1991); *radiata* pine from New Zealand (U.S. Dep. Agric. 1992) and Chile (U.S. Dep. Agric. 1993); pine and fir from Mexico (Tkacz et al. 1998), and, most recently, eucalyptus from South America (U.S. Dep. Agric., in preparation).

Invasive forest pests also have been detected in nonforest commerce. From 1995 to 1998, some 500 shipments containing solid-wood packing material (SWPM) were intercepted as having quarantineable pests (U.S. Dep. Agric., Anim. and Plant Health Insp. Serv., Port Inf. Network). The threat of pest importation on containers with this material has become an international problem because of the composition, utility, and transportability of SWPM. Unlike precautions taken for production agriculture and forestry production, there were no quarantine pest lists for nor detailed inspections of shipments with this material until the SWPM pathway was recognized.

Used to package and protect commodities such as machinery, weightlifting equipment, metal, stone, tile, furniture, and appliances, SWPM usually is constructed of low quality wood that often contains bark and sometimes exotic pests. As it circulates in global trade, SWPM is damaged and repaired, stored in a variety of ecological regions, mixed with other SWPM material, and reused. As a result, it is impossible to determine its origin, composition, and pest exposure to invasive pests. This is particularly the case with wood pallets, which are used to transport a myriad of goods within countries and around the globe. Because pallet dimensions differ greatly among countries, considerable cooperation and ingenuity will be required before the international trading community adopts a standardized nonwood pallet.

√ Wood poor in quality and variable in composition
√ International mobility
√ Loss of identity
√ Pest infestation origin
√ Difficulty of pest detection
√ Multiple pathways
√ Disposal methods

Figure 2. Problems associated with solid wood packing material.

Wood pallets and crating are the major components of SWPM, but they differ in use as maritime (59% pallets, 30% crating) and air (29% pallets, 71% crating) cargo. Dunnage, loose packing material used to protect ship cargo, constitutes only 7% of maritime wood packing material but often is reused and poses a high risk of harboring invasive pests, and is difficult to inspect

(Dawson et al. 1980). Dunnage is commonly associated with heavy machinery in containers that may not be declared on a ship's manifest as containing SWPM. Of the 1,205 pest interceptions arriving in the United States on SWPM from 1996 to 1998, 80% was in maritime cargo, 13% in air cargo, and 7% at land border crossings. Designated general cargo comprised 86% of the interceptions (U.S. Dep. Agric., Anim. and Plant Health Insp. Serv., Port Inf. Network). Between 1996 and 1998, Asia was the primary origin of intercepted SWPM pests and China was the primary source. Interceptions of forest pests on Chinese SWPM totaled 1.2% in 1985, 21.2% in 1996, and 39% in 1998 (U.S. Dep. Agric., Anim. and Plant Health Insp. Serv., Port Inf. Network). This trend was similar in Canada (Cen. for Plant Quar. Pests, Can. Food Insp. Agency). It is not clear whether these increasing interceptions were due to more highly infested SWPM or from accelerated inspections of goods from China.

Not surprisingly, the most commonly intercepted insect pests were Coleopterans (nine families) with Scolytidae and Cerambycidae the most numerous (Haack and Cavey 1997). Past established pest species—pine shoot beetle (*Tomicus piniperda*), European spruce beetle (*Ips typographus*), and Asian longhorned beetle (*Anoplophora glabripennis*) are believed to have been introduced via the SWPM pathway. The Asian longhorned beetle has been intercepted at 22 U.S. locations, and major established infestations are extant in the Chicago and New York areas. Native to China, Japan, and Korea, the longhorned beetle bores into and kills numerous hardwoods (poplar, alder, willow, maple, and fruit trees) (Haack et al. 1997). To date, infestations have been associated with streetside maple and horsechestnut trees (U.S. Dep. Agric. 1997). Eradication efforts including tree removal, chipping, and burning have been contentious issues in these urban environments. The most valuable commercial forest resource at risk is the extensive sugar maple products industry as sugar maple is a highly preferred host. Also at risk is the associated hardwood/foliage/tourism industry of the northeastern United States and Canada.

Invasive forest pests can accompany imported SWPM in a variety of ways. If bark has not been removed, insect and pathogen life stages may be deposited on or within cracks and crevices in the bark. Green or unprocessed wood may harbor bark beetles, deep wood borers, nematodes, or pathogens. Even after wood has been processed, organisms such as termites, powder post beetles, and stain fungi can infest it and survive shipping. Overwhelmingly, insect interceptions exceed those for pathogens (U.S. Dep. Agric., Anim. and Plant Health Insp. Serv., Port Inf. Network). This may be due to incipient infection of pathogen-infested wood or difficulty in detecting and culturing these organisms.

Repeated interceptions and established infestations of Asian longhorned beetle prompted the USDA Animal and Plant Health Inspection Service to enact regulations to close the SWPM pathway (Wood Importation Regulation 319.40-3(b), USDA-APHIS 1995). SWPM imported with nonwood commodities must be free of bark regardless of country of origin. SWPM originating from China, including Hong Kong, and destined for the United States not only must be bark free but also either heat-treated without moisture reduction, kiln dried, fumigated with methyl bromide, or treated with a preservation pressure treatment.

What does the future hold? Introductions of invasive insect pests will continue and the types of organisms and their pathways will expand. International political disputes will intensify as invasive pest regulation associated with SWPM becomes a major trade issue. Also, emerging markets will present challenges in predicting new pests, pathways, and products. Clearly, nations differ in their ability to detect and interdict invasive pests. Perhaps it is appropriate to consider that, as global trade and regulatory activities related to exotic pests become more harmonized, the costs of preparedness for new incursions should become a shared international responsibility.

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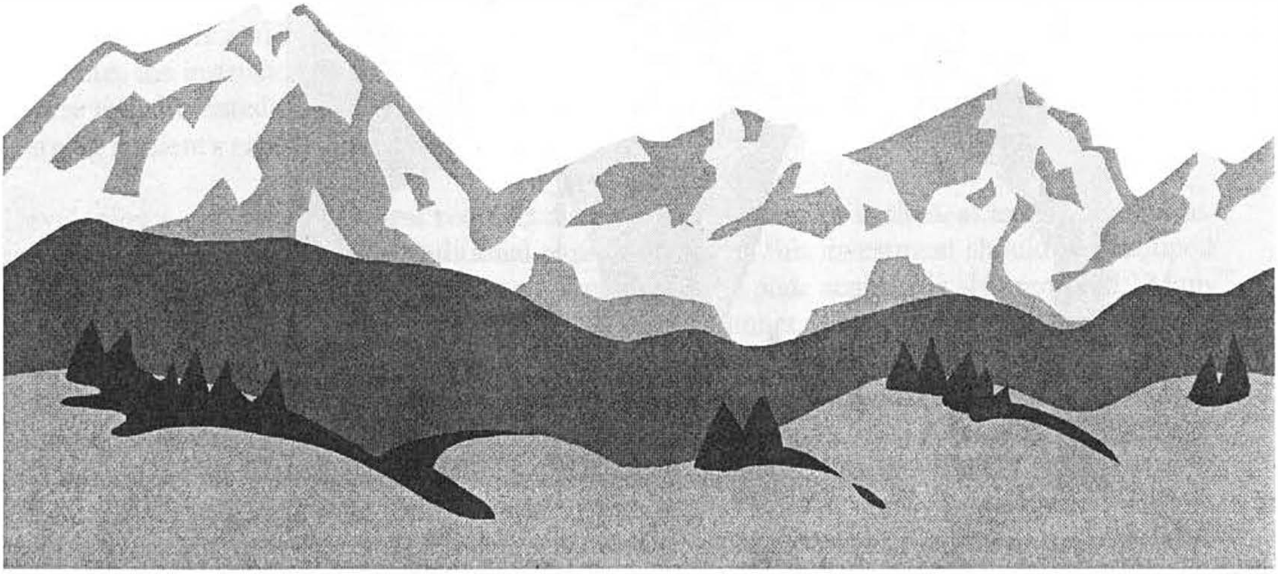

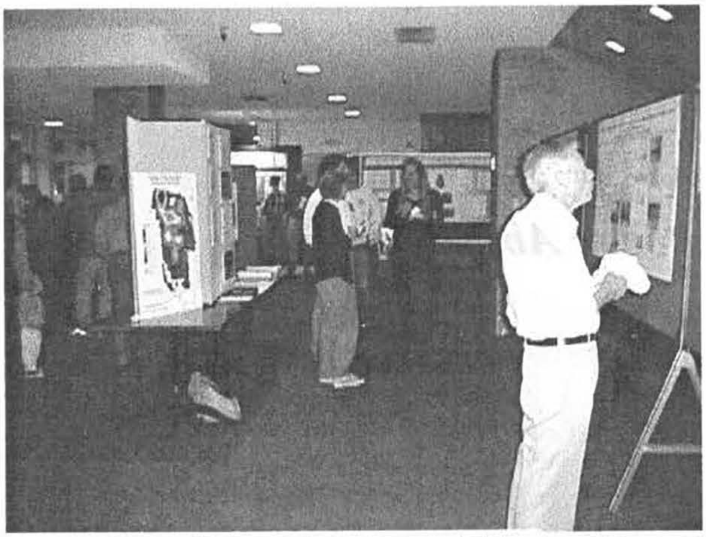

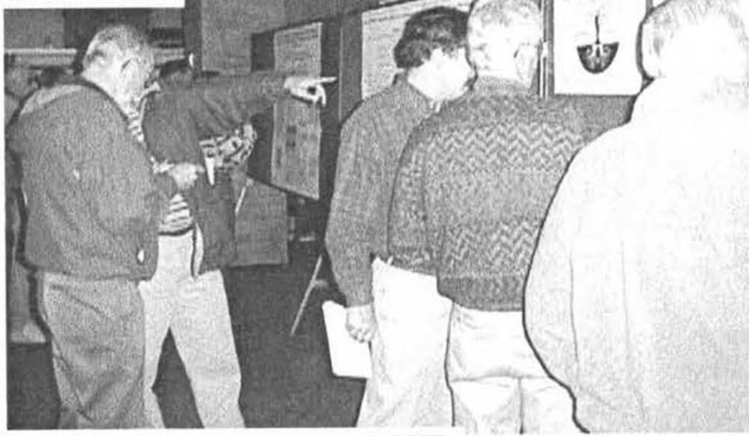

Using the World Wide Web in a Forest Pathology Course: Roadkill on the Information Highway

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Web-assisted learning provides a unique opportunity for students and teachers. Students can access course materials, assess their learning, view their progress and grades, and contact the instructors and other students in real time. While web-based learning cannot replace face-to-face instruction, in can increase student learning. A software package called WebCT makes design and implementation of a web-assisted course easy for instructors.

WebCT stands for Web Course Tool. WebCT is a tool that facilitates the creation of sophisticated World Wide Web-based educational environments. It can be used to create entire on-line courses, or to simply publish materials that supplement existing courses. WebCT requires minimal technical expertise on the part of the developer of the *educational material*, and on the part of the student. WebCT was developed in the Department of Computer Science at the University of British Columbia. This program integrates all of the tools needed to implement the web site, chat rooms, online gradebook, calendar, e-mail, and access to multi-media including CD-Roms, streaming video, and sound into a user-friendly environment. All of these tools need not be used in every course, allowing the instructor to tailor the site to the needs of the specific course. A very basic knowledge of HTML is all that is needed to build a fairly complex site.

The Forest Pathology web site lives at http://webct.usu.edu Follow the course listing to FR, then FR5420. This site is password protected, which allows entry only to students in the class. Visitors may access the site using the user name demo and the password demo (both must be lower case.) The opening page contains icons for the various functions available to the students. Students use the calendar to keep track of lecture and lab assignments. These are also listed under the lecture and lab icons. Links to web pages for the teaching assistant, the rhetoric associate, the instructor, and other useful websites are included. Old exams and those for this course are also listed on the web site. Student pictures were placed on the site to help with learning student's names.

Developing a web assisted course requires a significant investment in time, at least 4-5 times as much effort as teaching a more traditional course. Much of this investment should be recouped in future versions of the course. Access to a scanner and a slide scanner is also required. Many of the slides used in this site were scanned on a flatbed scanner with a transparency adapter. While not necessary, a digital camera helps greatly in acquiring web images.
Adobe Photoshop was used to modify slides, and Microsoft PowerPoint was used to develop the slide presentations for the web. Adobe Acrobat was used to make PDF files of course handouts and readings. WinZip was used to simplify file transfer from a pc to the WebCT server. An HTML editor was sometimes used to develop web pages, but was really not necessary. All of this software and hardware is attached to a normal desktop pc. Most if not all of the software comes with the computer and the scanner. Rudimentary HTML editors are available to

educators as freeware or as shareware. If you plan to develop a web-based course for next year, I recommend you start now learning the software and scanning the images.

The 1999 Forest Pathology course found the site to be very useful. Most students came to class with the lecture outline for that day. Students who missed class used the outline to guide their reading in the text. Students almost unanimously found access to the slide shows very useful, especially before quizzes and exams. Student scores were correlated with the number of times they accessed the site.

This site was started one week prior to the start of the class, which made it very difficult to keep the site current with lectures. Some slide shows were never placed on the web site. Time was not available to develop on-line practice and real quizzes. These would allow students to ensure that they have learned the key concepts before exams. When these tasks are complete, I will work with an education specialist to increase the effectiveness of the site to enhance student learning. Pending copyright problems, instructors could share lessons, spreading the effort among many instructors, and capitalizing on the strengths of each instructor to deliver a better course in Forest Pathology.

Web-assisted courses can increase student learning, increase the effectiveness of teaching, and although there is an initial, significant increase in instructor effort, web-assisted courses can reduce instructor effort, especially in large classes. Students greatly appreciate the convenience of access to course materials from home or elsewhere on campus. A web-assisted course can be the first step toward a web-based course.

The WebCT website can be found at www.webct.com.

Regional Differences in Two Mountain Pine Beetle Population Fitness Parameters

Barbara J. Bentz, Jesse A. Logan, and Jim C. Vandygriff, Rocky Mountain Research Station, Logan, UT

Throughout the range of the mountain pine beetle (*Dendroctonus ponderosae* Hopkins), observed differences in several population fitness parameters such as development time, brood production, cold hardiness, and adult and larval size have been attributed to the host species brood develop within. Alternatively, observed differences may be largely due to the environment in which the broods develop, varying significantly across geographic regions irrespective of the host type. It is important to understand what factors are responsible for observed differences in population fitness parameters and ultimately the success of a population. If there are true differences among mountain pine beetle populations that are based on either host type or geographic region, it may be necessary to develop individual management strategies and population prediction and risk models for each region and/or host type. We investigated the role of host type and geographic region on mountain pine beetle population performance using 2 fitness parameters: 1) development time from the egg to adult, and 2) adult size. F_0 brood included: lodgepole pine (Sawtooth National Recreation Area near Stanley, ID), ponderosa pine (Dixie National Forest near Cedar City, UT) and western white pine (Spotted Bear Ranger District, Flathead National Forest). F_2 brood developed in either lodgepole pine or ponderosa pine. Development time and adult pronotal size of F_2 brood were measured. If the F_0 source host has a greater effect on F_2 brood development time and adult size than does the host F_2 brood were reared in, we hypothesized that some heritable factor related to the F_0 parents was responsible for observed differences.

Conclusions

1. F_0 parent beetles had a greater effect on F_2 brood development time and adult size than did the host brood developed in. In all treatments, F_1 parents were reared in the same host. Although F_0 parent beetles were from both different hosts and different geographic regions, the effect of geographic region was much stronger ($\square^2 = 4.94$ for brood host effects as compared to $\square^2 = 1291.0$ for source effect).
   - These results suggest that mountain pine beetle populations in different geographic regions have heritable traits that are maintained despite the brood host, at least through two generations.

2. F_2 brood adults from F_0 source beetles from central Idaho always developed the fastest despite the host brood were raised in. These beetles were also always the smallest. In contrast, F_2 brood adults from F_0 source beetles from southern Utah always developed the slowest, yet these beetles were always the largest.
   - These results suggest that a strong local selection pressure such as microclimate may be influencing mountain pine beetle populations in different geographic regions. Temperatures in southern Utah are much warmer than temperatures in central Idaho (Bentz and Mullins 1999). Selection pressure in the colder environment would maintain a faster development time, whereas in the warmer climate, where the season for

development is longer, selection for a larger size would be stronger. Model analysis (Logan and Bentz 2000) of mountain pine beetle seasonality also anticipated this observation.

3. Variation in the response of mountain pine beetle populations to field-applied semiochemicals may also be explained by geographically-mediated heritable traits. The application of semiochemicals for population manipulation, as well as, population and risk models which drive management decisions may need to be tailored to each geographic region.

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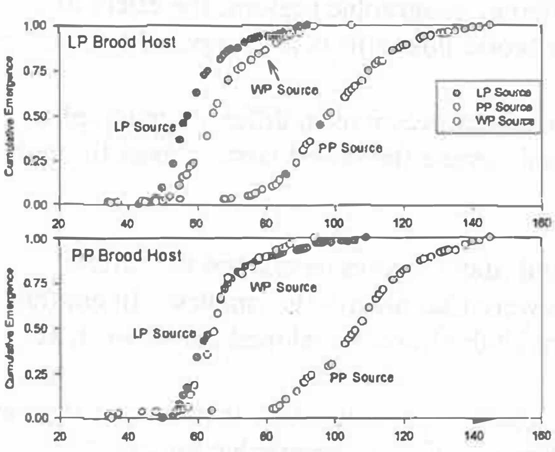

Figure 2. Development time for F_2 brood adults reared in LP and PP by F_0 source.

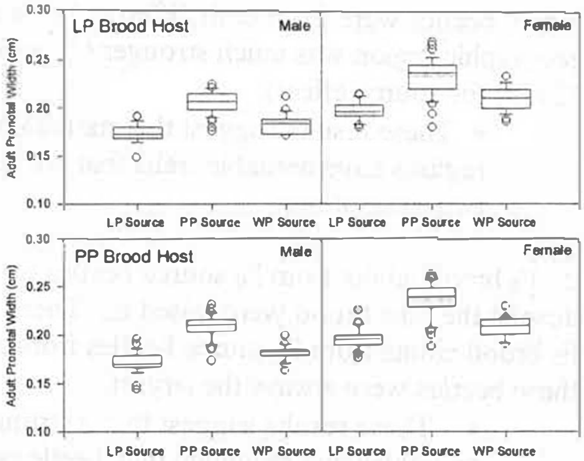

Figure 4. Box plots showing the effect of F_2 brood host on F_2 brood adult pronotal width, by F_0 source.

Screening Port-Orford-Cedar for Resistance To *Phytophthora lateralis*: Results from 7000+ Trees Using a Branch Lesion Test

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As part the process of developing an operational program breeding for genetic resistance to a root disease of Port-Orford-cedar (*Chamaecyparis lawsoniana*) caused by *Phytophthora lateralis*, an inter-agency effort has been undertaken to select and screen phenotypically resistant trees throughout the range of Port-Orford-cedar. The USDA Forest Service, USDI Bureau of Land Management, and Oregon State University (OSU) have selected over 7000 trees across south-west Oregon and northern California, predominantly on federal lands. Generally, these selections were healthy trees in areas where *P. lateralis* is known to be present. Screening began at OSU in 1989, and different techniques were developed and used through 1996. Operational screening of field selections began in 1997, and through 1998, over 6700 clones were been screened using the branch dip method. This method had previously been found to identify at least the most resistant clones. Lesion length was measured on 6 branches per clone, and these measurements were compared with a resistant and a susceptible control tree. Relatively few of the clones screened in 1997 and 1998 had branch lesions means smaller than the resistant control. Approximately the top 10% of each run was selected to be included in the breeding program. Over 1000 clones are currently in the breeding program, for the purposes of retesting, crossing, and archiving these genotypes. The screening effort is continuing in 1999 with many areas of private land within the range of Port-Orford-cedar being targeted for selection and testing, with an ultimate goal of screening a total of 9000 trees.

The Role of Armillaria Root Rot in Host Selection by the Pine Engraver, *Ips pini*

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In forests dominated by lodgepole pine, *Pinus contorta* var. *latifolia*, trees infected with root pathogens are frequently attacked by scolytid bark beetles, in particular the pine engraver, *Ips pini*. Two experiments were initiated to determine the role of the root pathogen, *Armillaria ostoyae*, in host selection by *I. pini*. First, beetles were released within outdoor flight tents and allowed to choose between lodgepole pine bolts that were either uninfected or were inoculated under laboratory conditions with *A. ostoyae*. Second, an airflow olfactometer was constructed to assess the behaviour of beetles exposed to odour fields originating from lodgepole pine (bark, phloem and sapwood) alone or in combination with mycelia of *A. ostoyae*. Foraging *I. pini* preferred host material infected with *A. ostoyae*. In the flight tents, twice the number of male and female *I. pini* initiated galleries in the inoculated lodgepole pine bolts *versus* the controls. However, despite their preference for Armillaria-infected bolts, in the olfactometer *I. pini* did not prefer the combined odours of pine and *A. ostoyae* compared to pine alone. The lack of predilection for odours associated with *A. ostoyae* in the olfactometer suggests that when concentrations of Armillaria-related volatiles are high, such as those within the olfactometer, preference for pathogen-infected host material declines.

Forest Pests of North America Integrated Pest Management Photo CD Series

G. K. Douce, D. J. Moorhead, B. T. Watson and C. T. Bargeron, The University of Georgia, Cooperative Extension Service, P. O. Box 1209, Tifton, GA 31793 USA

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Management of Laminated Root Rot in an Urban Forest Park, Mercer Island, Washington

Robert L. Edmonds, College of Forest Resources, University of Washington, Seattle, Washington, 98195

Pioneer Park (120 acres) is located on south central Mercer Island, near Seattle, Washington. Vegetation consists of second-growth forest. Major tree species are Douglas-fir, western hemlock, western redcedar, red alder, big leaf maple, vine maple and Pacific madrone. Laminated Root Rot, Armillaria Root Disease, Annosus Root and Butt rot, Schweinitzii Butt Rot and Madrone Canker are present. The most important disease is Laminated Root Rot and it is causing considerable tree mortality. Theobjectives of this study were to: (1) determine the extent and spatial distribution of Laminated Root Rot in Pioneer Park, and, and (2) develop a management plan for Laminated Root Rot for the City of Mercer Island. InOctober, 1998 stereo aerial photographs of Pioneer Park were taken by Reinhard Schroeder of Aerial Reconnaissance Northwest, Inc. of Poulsbo, WA to identify individual dead trees and root disease pockets. Laminated Root Rot occurs in all three sections of the park with scattered individual root rotted trees as well as large well defined centers.

Management alternatives for Pioneer Park include: doing nothing, managing only for hazard trees (likely to hit power lines, roads or houses), managing only for the large root disease centers, and managing for all laminated root disease trees. The community using the park appreciates biodiversity and other than managing hazard trees, particularly along roads with power lines, allowing "natural" forest succession is a popular option. However, it appears that the park will become more dominated by hardwoods (red alder and big leaf maple) in this case. Underplanting of western redcedar in large root disease pockets has some merit. It is unlikely that stump removal or treatment with fumigant chemicals will be used.

The Status of Whitebark Pine Along the Pacific Crest Trail, Umpqua National Forest

Ellen. M. Goheen[1], R. Danchok[2], D. J. Goheen[1], K. Marshall[1], and J. Petrick[2]
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There is widespread concern about the status of whitebark pine throughout the west. Whitebark pine is an important species in the southern Oregon Cascade Mountains; however, its condition has not been evaluated in a rigorous fashion. During the summer of 1998 we began to assess the condition of whitebark pine in southwest Oregon by surveying the area along the Pacific Crest National Scenic Trail (PCNST) on the Umpqua National Forest. Twenty-one transects were installed along the PCNST. Sixteen of the 21 transects installed during this survey had whitebark pine on them. Total whitebark pine stocking measured on these transects ranged from 6 to 217 trees per acre with an overall average of 75 whitebark pines per acre. Eighty-seven percent of all whitebark pine measured were less than 15 feet tall. Whitebark pine stocking ranged from 0.1 to 24 percent of total tree stocking on individual transects. White pine blister rust was found on all transects that had whitebark pine. It occurred on 62 of the 79 (78 percent) whitebark pine plots. Across the survey area 52 percent of the live whitebark pine per acre were infected. Seventy percent of the whitebark pine greater than 4.5 feet tall and less than three inches in diameter were infected. The vast majority (92 percent) of the infected trees had bole cankers or cankers within six inches of the bole. Thirty four percent of all white pine blister rust-infected whitebark pine suffered topkill. Ten percent of the whitebark pine stocking in the survey area was dead. White pine blister rust was the most frequently encountered mortality agent. It was found on 84 percent of all dead trees. Evidence of mountain pine beetle (*Dendroctonus ponderosae*) was found with white pine blister rust on 18 percent of dead whitebark pine. Only one *Ribes* plant was encountered across the entire survey area. Anecdotal accounts are no longer the only source of whitebark pine information along the PCNST on the Umpqua National Forest. A 1998 reference condition for whitebark pine has been described for the area surveyed and can be used for assessing changes in the status of the species.

Larval Diapause Status of the Spruce Beetle, *Dendroctonus rufipennis* (Coleoptera: Scolytidae)

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The spruce beetle *(Dendroctonus rufipennis* (Kirby)(Coleoptera: Scolytidae)), an important mortality agent of spruces, has described life-cycles ranging from one to three years. Although temperature has been shown to be strongly associated with spruce beetle voltinism, it is not clear whether its physiological basis is diapause-related or directly under temperature control. Our experiments tested for reduced morphogenesis, the outward expression of diapause, by comparing development rates in "cool" temperature treatments against a reference (constant 21°C) for which there is no indication of larval diapause induction. Two experiments were conducted comparing the treatments against a reference, one using a constant temperature of 12°C and one using daily thermoperiod measured from a field site with 2-year beetles. Beetles were reared in their respective treatments through instar IV, then placed in constant 21°C, matching the reference conditions. Elapsed time from instar IV to teneral adult was then measured and compared among treatments and references. The constant temperature treatment was not significantly different than the reference. The thermoperiod treatment was found to be significantly different than its reference, although the difference was only a few days. The experimental design resulted in some beetles remaining the thermoperiod treatment longer than others and there was a significant positive relationship between duration in the treatment and development time after being returned to 21°C. These results suggest a physiological response beyond quiescence although it remains unclear whether this is "shallow", late-instar induced diapause or a non-diapause physiological response such as cold-hardening. It is our conclusion that spruce beetle voltinism is primarily under direct temperature control, and that the physiological response to "cold", regardless of its basis, serves to reinforce the life-cycle course governed by temperature-related phenology.

Evaluating the Dead Yellow-Cedar Resource on the Tongass National Forest

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We have documented the distribution of yellow-cedar decline from aerial surveys that are conducted annually. Dead and dying stands of yellow-cedar cover nearly 1/2 million acres in Southeast Alaska; most of the acreage is on National Forest lands. This information is available as a GIS layer, but to make this layer more useful to managers, we need to classify the occurrence by volume and concentration of dead trees.

A 5-class snag system, relating time-since-death to foliage and branch retention, is the basis for sampling in all the studies described here. The average age since death for each of the 5 classes is as follows: class 1 is 4 years, 2 is 14 years, 3 is 26 years, 4 is 51 years and class 5 is 81 years. Most declining forests have dead trees in each class, as well as surviving yellow-cedars and trees of other species.

As a yellow-cedar tree dies, the sapwood is quickly colonized by stain and decay fungi. The narrow sapwood on yellow-cedar is fully colonized by fungi and insects, then it begins to slough away at the third snag class. Up to this stage, however, any defect (stain, decay, checking) is restricted to the sapwood and does not penetrated to the heartwood. By class 4, the sapwood is nearly gone and the heartwood becomes checked--the most serious defect. This pattern of deterioration helps explain the high volume and grade that is yielded from the first 3 snag classes.

With assistance from Pacific Rim Cedar, Inc., we measured the cubic volume recovered from over 300 logs of dead and live yellow-cedar trees that were harvested near Nemo Point on Wrangell Island. This was possible by marking trees in the woods and following their logs to individual boards as they were sawn at the mill site. Each board was given a domestic and export grade. Class 4 and 5 snags yielded significantly less domestic volume than the more recent classes of snags or live trees, but the reduction was less than 15%. Recovered wood meeting the more restrictive export rules was considerably lower and more variable among tree/snag classes but showed the same general pattern as domestic recovery. The lumber grade for recovered volume did not differ greatly by tree/snag class, but there was a trend for more of the volume recovered in poorer grades to be from the older snag classes. High-grade pieces of lumber were produced from all five snag classes including those dead about 80 years. Generally, these results demonstrate an encouraging rate of recovery from dead yellow-cedar.

Yellow-cedar is known for the strength of its wood. Results from the first phase of testing at the Forest Products Laboratory indicate no reduction in the strength properties of wood from snags, even long after death. Larger sample sizes are included in the second round of sampling of dead trees from Wrangell Island; results should be available soon from David Green at the Forest Products Laboratory.

We are addressing the question of whether wood from dead yellow-cedar retains its remarkable decay resistance when used in service. This work includes laboratory and field tests on the durability of snag wood with Doug Crawford of the Forest Products Laboratory. Chemists Rick Kelsey and Joe Karchesy are measuring the concentration of nootkatin and other heartwood constituents from the wood of each of our snag classes to determine if these compounds are lost through time as snags remain standing.

The high economic value of yellow-cedar wood can justify helicopter yarding to recover volume from these dead trees. Such a light treatment on affected sites, with the retention of green residual trees, results in a harvest that is difficult to detect visually when viewed from a distance.

The ecological roles of dead yellow-cedar need to be evaluated as more of the dying stands are treated. Along with Toni DeSanto, avian ecologist at the Forestry Sciences Laboratory, we have initiated a study to determine if birds use dead yellow-cedar trees as nesting or feeding habitat. We have also established a companion study with Mark Schultz to evaluate insects associated with the snag classes, which may link to feeding by insectivorous birds.

Taxonomic Clarification of the *Perenniporia subacida* Complex Through Molecular and Microscopic Analysis: A Proposed Study

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Perenniporia subacida, *P. ellipsospora* and *P. medulla-panis* are three species of white rot fungi that decay both conifers and hardwoods. The species concepts of these taxa need clarification. Microscopic comparisons will be made between species, focusing on basidiospores, basidia, and the hyphal systems. Compatibility tests will be conducted from fungal cultures, and PCR and DNA sequencing will be utilized to construct a phylogeny of the *Perenniporia subacida* Complex.

The Anatomy of Black Stain Root Disease Centers in Pinyon Pine

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Black stain root disease, a vascular wilt disease of pinyon pine (*Pinus edulis*) caused by the fungal pathogen *Leptographium wageneri* var. *wageneri,* was first identified in Colorado at Mesa Verde National Park in 1942. The early 1990's saw a rise in the amount of pinyon mortality in the San Juan National Forest and nearby forests in southwestern Colorado. Pinyon – juniper woodlands comprise the largest forested cover type in Colorado and concerns about pinyon mortality have been raised by the increasing residential and recreational populations. In the summer of 1999, a study was undertaken in order to examine the effects of *Leptographium wageneri* var. *wageneri* on pinyon - juniper woodlands in southwestern Colorado. Thirty mortality centers with visually confirmed black stain were located on the San Juan NF and Southern Ute Reservation in SW Colorado. Three transects were established within each mortality center. One-hundredth acre shrub and seedling plots were established at the mid-point of each transect and thirty feet beyond each transect in which the percent shrub cover by species and the number of tree seedlings were recorded. Two - twenty by fifty centimeter plots were established at both the mid-point of each transect and thirty feet beyond each transect in which the percent herbaceous cover by species and the percent cover by bare soil, litter, and rock were recorded. The following conclusions have been derived from preliminary analyses of data collected. Mortality centers contain both pinyon regeneration and surviving pinyon. There were no significant differences in the numbers of pinyon seedlings between mortality centers and surrounding areas. Seedling density of juniper species was higher within mortality centers than surrounding areas (27/ac and 13/ac respectively). Shrub cover does not change significantly in the percent coverage or the number of species present between mortality centers and surrounding areas. Herbaceous cover is significantly higher within disease centers than surrounding areas (20.2% and 9.4% respectively). Work remaining includes analyses on biodiversity differences, analyses on tree rings in order to age time of mortality and determine a rate of expansion, analysis of GPS data of plot boundaries, and isolations from dead pinyon roots to determine if the pathogen can remain viable within dead trees.

Emerging Species Concepts in the *Phellinus pini*-Complex

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Tina Dreisbach, USDA Forest Service, Pacific Northwest Research Station, Corvallis, ID
Alan Harvey and Jill Hoff, USDA Forest Service, Rocky Mountain Research Station, Moscow, ID

Introduction

Phellinus pini (Brot.: Fr.) Ames is a name that has been applied to what appears to be a highly variable species, morphologically, one that causes internal defect in all conifers species in North America. However, Owens (1936) suspected there may be subspecific taxa within the existing species concept of *P. pini*, but concluded that the data were inconclusive on this point. Fischer (1994, 1996) concluded that in western North America there were seven biological species, some of which appeared to be host specific. Dreisbach and Hansen (5th Int. Mycol. Congr., Vancouver, Canada, 1994), using DNA analysis, tentatively concluded that *P. pini* as originally described from Portugal does not occur in western North America. Their analysis used isolates from local collections of what was considered *P. pini* and *P. cancriformans* (Lars. et al.) Lars. et Lomb. and compared those to isolates from the recently designated neotype of *P. pini* from Portugal (Larsen and Melo 1996). In addition, they concluded that *P. cancriformans*, which causes both internal defect and cankers on *Abies* spp. in the west, was a distinct species. Larsen and Cobb-Poulle (1990) summarized the nomenclatural status of the world taxa of *Phellinus* based on existing data and proposed synonymy in the literature; only *P. pini*, *P. chrysoloma* and *P. cancriformans* (of the *P. pini* complex) were recognized.

Cerny (1985) concluded that specimens from North America should be called *Phellinus vorax* (Harkn.) Cerny (nomen nudum; a name that was not validly published) and that *P. pini* does not occur in North America. This opinion is also held by Fischer (1994, 1996). Cerny (1985) also placed *Phellinus piceinus* (Peck) Pat. in synonymy with *P. vorax*. Larsen and Stenlid (1999 in press), while neotypifying *Phellinus chrysoloma* (Fr.) Donk, studied the nomenclatural types of *P. piceinus* and *P. pini* and concluded that, along with *P. chrysoloma*, they represent three distinct species.

The situation in western North America

Our studies on this complex suggest that an additional species exists. It occurs on *Picea sitchensis* (Bong.) Carr and for the present we are calling it *Phellinus sitchensis* in ed. In the western United States, we are aware of three distinct species that were formerly referred to *P. pini, e.g., P. cancriformans, P. vorax* and *P. sitchensis* in ed. To date, we are not aware of the existence of any data that would confirm the occurrence of *P. pini*, *P. chrysoloma* or *P. piceinus* in this region. We wish to note at this juncture that the latter two species are known to be associated only with saprotrophic decay, while the others cause internal defect, and cankering (in one species) of live standing conifers.

They may be identified using the following criteria:

> *P. cancriformans:* associated with stem cankers of *Abies* spp. Cankered area with multiple imbricate basidiomata, tramal setal hyphae bent abruptly and projecting through the hymenium. Found throughout the coast range from northern California north to Oregon.

P. sitchensis in ed: associated with internal defect of *Picea sitchensis*, sterile tissue mass produced giving rise to basidiomata, setoid structures produced in sterile tissue. Found at the southern region of the temperate rain forest and probably throughout the range of sitka spruce.

P. vorax: associated with internal defect of coastal *Pseudotsuga menziesii* and numerous other conifer species in the Idaho Panhandle, particularly *Larix occidentalis* Nutt. Pore surface becoming coarsely daedaloid. Basidiomata not associated with sterile tissue mass.

Changes in species composition of western North American forests, from seral pines and larch to white fir types (*Abies* spp.) (Harvey et al. 1995), indicate that we can expect pathogens like *Phellinus cancriformans* to increase activities on these hosts. Hosts not only become more widespread, but they occur in very dense stands. Thus, they are likely to be highly stressed and more susceptible to endemic (or introduced) organisms than in the past (Harvey 1994). Increasing our understanding of the taxonomy and ecology of this group of pathogens, both those that are endemic and those that could be introduced, will be critical to predicting the health and productivity potential of regional forests in the next millennium.

Conclusions

Based on ecology, data derived from macro- and micro-morphological characteristics, intersterility tests, DNA analyses, and to some extent, host specificity, we conclude that ***Phellinus cancriformans*, *P. sitchensis*, and *P. vorax* represent distinct taxa of *Phellinus* in western North America.** Our observations lead us to believe the *P. pini* is limited to the European continent.

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Odors for Host Location in Three Pteromalid Bark Beetle Parasitoids.

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Oxygenated monoterpenes, associated with the bark beetle hosts, are of particular importance in host location. This was found to be the case in the pteromalid parasitoids *Rhopalicus tutela*, *Roptrocerus mirus* , and *Roptrocerus xylophagorum* that are natural enemies of several bark beetle species (Coleoptera: *Ips spp.*, *Dendroctonus spp.*). These parasitoids attack late instar larvae and pupae in pupal chambers concealed under the bark of conifers. Volatiles are probably the most important cues in host location among these bark beetle parasitoids since no visual cues are available, and previous research has revealed that heat- or vibration cues are not of major importance in host location of bark beetle parasitoids. Volatiles associated with susceptible hosts were examined. Oxygenated monoterpenes elicit responses in bioassays (Y-tube) and in electrophysiological recordings (GC-EAD), while monoterpene hydrocarbons, constitutive odors from the host trees, do not elicit any significant EAD-responses. Both natural and synthetic baits were investigated by chemical (GC-MS), behavioral, and electrophysiological studies.

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Balsam Woolly Adelgid Survey and Assessment in the Pacific Northwest

Iral Ragenovich, Karen Ripley, and Elizabeth Willhite

The balsam woolly adelgid (BWA), *Adelges piceae*, is an introduced insect that has had significant impact on grand fir, Pacific silver fir and subalpine fir in Washington and Oregon. During the 1950's and 1960's it caused extensive mortality primarily along the Cascade Range. Since that initial mortality, BWA damage has been chronic and subtle. The aerial detection survey is one of the primary means of gathering forest health information. BWA damage often is not visible or is misidentified in the aerial survey.

The objectives of this project are to conduct a ground survey of the host type throughout Washington and Oregon to confirm occurrence and distribution; determine effects on host species and changes in local ecosystems; and determine whether existing parameters for occurrence and risk still hold true today.

A Risk/Occurrence Map was developed using historical aerial survey information and the risk parameters of host type and elevation developed by Mitchell in the early 1960's. We also identified areas where it was suspected that BWA should occur but had not been reported. In 1998, we began the ground survey, focusing primarily on northwest Oregon and southwest Washington, the Olympic National Park and the Cascade Range in northern Oregon. In addition, permanent plots that were established in the early 1960's were revisited to collect information on continued BWA activity and effects. The ground survey was continued in Oregon's central and southern coast range, and along the central Oregon Cascades in 1999. The survey will be completed in Oregon and Washington during 2000.

A Mountain Pine Beetle Decision Support System

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The mountain pine beetle (*Dendroctonus ponderosae* Hopkins) is the most destructive forest insect pest in western North America. It attacks and kills millions of mature pine trees each year. In the past five years losses in B.C. have totaled over 8 million cubic metres of wood, almost twice the volume lost to fire. At the peak of the most recent epidemic, trees were killed over 500,000 hectares in B.C. The magnitude of these losses has caused serious disruptions to the timber supply in the B.C. interior, and the beetle, rather than man, has dictated forest management planning. Management of the mountain pine beetle problem is evolving from a "fire fighting" approach to a preventative approach. There is a strong demand from forest managers for tools that will assist them in identifying high risk stands and in helping them to select stand and pest management options that will minimize the losses to the mountain pine beetle.

In 1992 a project was started by the Canadian Forest Service to develop a decision support system for the mountain pine beetle. The intention of this system is to bring together knowledge of the pest and its management in a suite of tools in a user-friendly computer environment. At the heart of the system is a stand susceptibility and risk rating system (Shore and Safranyik 1992). The system brings together data on mountain pine beetle and forest inventory to create susceptibility and risk rating indices and maps. The current and potential impact of a mountain pine beetle epidemic can be estimated on a landscape basis using these indices (Shore et al. 2000), or on a stand basis using a population dynamics and impact model. The making of informed decisions regarding strategies and tactics for mountain pine beetle management is facilitated by a management decisions expert system, and a supplied literature database. The relative effectiveness of these strategies and tactics can be further explored using the population dynamics and impact model.

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Genetic Resistance of Port-Orford-cedar (*Chamaecyparis lawsoniana*) to *Phytophthora lateralis*: results from early field trials

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Field trials of Port-Orford-cedar (*Chamaecyparis lawsoniana*) (POC) established by the USDA Forest (USFS), USDI Bureau of Land Management (BLM), and Oregon State University (OSU) at two sites in 1993 and three sites in 1998 provide early information on genetic resistance to a POC root pathogen, *Phytophthora lateralis*. This information adds to the results of an older small planting on the OSU Botany Farm. Family 510015 was the top survivor among the 28 open-pollinated families planted in 1993, with a mean survival of 50% versus a mean of 23% for all families through 1997. Family 510015 was also among the top performers in root lesion and branch lesion tests following artificial inoculations. In the 1998 plantings, crosses involving clones 510015 or CF1, or crosses involving progeny of 510015 were rated among the best for lesion score. CF1 had previously shown good survival in the older clonal planting on the OSU Botany farm where all susceptible clones have died. At this point only a few parents show relatively strong resistance, but screening of thousands of phenotypically resistant parents is underway. The underlying mechanisms of resistance are not known at this point.

Tree-ring reconstruction of western spruce budworm outbreaks in the San Juan Mountains

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Tree-ring records were used to reconstruct the spatial and temporal patterns of western spruce budworm (*Choristoneura occidentalis* Freeman) outbreaks on the Rio Grande National Forest (RGNF) in the San Juan Mountains of southern Colorado. Records from 11 host stands showed a synchronous pattern in outbreaks with a peak in the number of trees recording outbreaks on average every 24 years. These synchronous periods of outbreaks corresponded to periods of increased moisture as indicated by an independently reconstructed summer Palmer Drought Severity Index. Conversely, relatively few trees recorded outbreaks during dry periods. Although outbreaks on the RGNF have been synchronous, the most recent outbreak may have had increased synchrony in the start year and the number of sites affected. Possible explanations for this potential increased synchrony in the most recent outbreak include: 1) a greater homogeneity of forests at a landscape scale resulting from timber harvesting and fire suppression, 2) climate patterns, particularly the increased precipitation in the southwest since the mid 1970's, or 3) potentially the subjective selection and sampling of the sites. Overall, the reconstruction did not exhibit the level of changes in outbreak patterns in the 20th century that have been noted in other tree-ring reconstructions.

Yellow-Cedar Heartwood Stain: What Causes the Concentric Bands of Stained Wood?

Mark Schultz, Paul Hennon, and Dustin Wittwer, USDA Forest Service, State and Private Forestry, Forest Health Protection, Juneau, AK.

The stumpage price of yellow-cedar is many times that of Sitka spruce or western hemlock, the two other commercial tree species in Southeast Alaska. Blue stain considerably devalues yellow-cedar in the Japanese market. The concentric patterns of stained wood occurred approximately 40, 100, 200, and 300 years ago (on average) in trees at the Nemo site, Wrangell, Alaska. Each band of stained wood is limited to the sapwood, which is converted to heartwood when new unstained sapwood is formed. Several stain fungi have been isolated from yellow-cedar in other studies but only two were identified, *Phialospora melinii* and *Sporidesmium* sp, from isolations of stained wood in this study. Wounds and insect galleries associated with these stain patterns lead us to hypothesize that wood boring insects were involved in the infection process. A woodwasp was found within some of the more recently stained trees. A longhorned beetle, *Opsimus quadrilineatus,* was found on yellow-cedar bark; yellow-cedar sapwood could be the host-substrate of this beetle. Within Southeast Alaska the distribution of trees with the number and pattern of concentric bands of stained wood might be different than the distribution of yellow-cedar decline. Information on the causal factors and the distribution of this stain in Southeast Alaska would be useful in forest planning. Yellow-cedar wood will continue to be a valuable forest product.

Spruce Beetle and Plant Succession in the Glacial Rebound Areas of Glacier Bay National Park

Mark Schultz, Paul Hennon, and Dustin Wittwer, USDA Forest Service, State and Private Forestry, Forest Health Protection, Juneau, AK.

Pioneer stands of predominantly Sitka spruce occur on glacial rebound sites in lower Glacier Bay National Park. Conditions (nutrient immobilization, blow-down, and dry weather) were optimal for a spruce beetle (*Dendroctonus rufipennis*) outbreak in the late 1970's. In 1982, 45 fifth-acre plots were installed on Lester Island, onYoung Island, near Berg Bay, near Ripple Cove, and north and south of Barlett Cove. Though the plot trees were generally bigger at Berg Bay and Ripple Cove, tree basal areas were between about 250 and 350 square feet per acre. The greatest average reduction in basal area due to spruce beetle mortality was for the Young Island plots. These plots had some of the youngest Sitka spruce, 30 to 50 years younger than trees at the other locations. By 1979, the average growth rate of trees declined to almost 0.5 mm in diameter per year. This slow growth was attributed to nutrient immobilization. When spruce beetle populations increased in windthrown trees; live slow-growing trees were attacked and killed. Beetles often strip attacked trees one or two years before they killed trees. Windthrow became more common after stands were thinned by spruce beetle mortality. There was good regeneration on most of the plots. There will be a conversion of many of these sites to western hemlock. The loss of Sitka spruce will have an unknown effect on wildlife.

Resistance of Coastal Douglas-fir to *Phellinus weirii*: A Research Update

Rona Sturrock, Garry Jensen, and Arezoo Zamani, Canadian Forest Service,
Pacific Forestry Centre, Victoria, BC

Introduction -- *Phellinus weirii* (Murr.) Gilb., causing laminated root rot (LRR), is the most serious root pathogen affecting coastal Douglas-fir (*Pseudotsuga menziesii* var. *menziesii*) in western North America. The fungus survives in infected stumps and roots and if this inoculum is not removed, normally at the time of harvest, *P. weirii* continues to grow in subsequent generations of susceptible conifers.

Genetic resistance is one of several management strategies available to combat LRR. Given that both the host and the pathogen are indigenous to the forests of the Pacific Northwest, sources of natural disease resistance should have evolved. A recent screening trial, where 97 full-sib families of coastal Douglas-fir (Fdc) were inoculated with two isolates of *P. weirii* using a novel inoculation technique (Sturrock and Reynolds 1998), provided evidence of genetically-based resistance of Fdc to *P. weirii.*

Fifteen families (five each per high-, mid-, and low-tolerance rank) from the British Columbia Ministry of Forests (BCMOF) Fdc Tree Improvement Program have been selected for closer investigation regarding resistance factors. Seedlings from these families were outplanted to a nursery site in May 1999 and around naturally-infested stumps in a cut-block near Campbell River, BC. The nursery seedlings will be inoculated with *P. weirii* in the Fall of 1999; disease development and host reactions will be monitored closely at both sites.

Little is known about the infection biology of *P. weirii* on Fdc, nor about the biochemistry of the host-parasite interaction. This knowledge is essential to understanding and utilizing resistance factors so that *P. weirii*-resistant-Douglas-firs may eventually be confidently deployed in root rot areas.

A documentary study of the *P. weirii* infection process was initiated in March 1999 with the artificial inoculation of sixty, 28-year-old Fdc's. A sample of these roots will be excavated monthly (2 roots/tree X 5 trees/month) for one year. Excavated roots will be assessed in the laboratory for ecto- and endo-mycelial growth, infection points and hosts reaction(s) using both specialized measurements and histological techniques.

Current Work – Our current work focuses on three principle areas:

1. Identification and characterization of pathogenesis-related (PR) proteins in infected Fdc tissues.
2. Elucidation and description of the infection process on artificially inoculated Fdc roots.
3. Construction of cDNA libraries for *P. weirii* and for infected Fdc root bark to investigate molecular mechanisms in the Fdc-*P. weirii* interaction and identify potential molecular markers for breeding and genetic engineering.

Results to Date and Discussion

1. An endochitinase-like protein (ECP) is known to be up-regulated in Fdc root and stem bark infected with *P. weirii* (Robinson et al. in press). Expression of the ECP does not appear to correlate with proposed tolerance levels for the 15 selected families. The function of this protein is not known; research to confirm its chitinase activity is currently underway.

2. Ectotrophic (surface) mycelia of *P. weirii* are known to advance along newly infected roots and eventually penetrate through the phloem to the host's vascular cambium and xylem. Our documentary research of the infection process thus far suggests that the fungus has several entry points along roots and that some, but not all, Fdc roots produce pitch and try to wall off the fungus.

   Histological investigation of infected tissues from some of the 15 selected Fdc families suggests that invasion occurs in all cases but in tolerant individuals the host is able to recover from attack. Slides reveal repeated events of host phloem tissue death followed by a walling-off of infected tissues by necrophylactic periderm. In cases where the vascular cambium is killed, callusing and vascular cambium restoration may occur followed by resumption of normal growth. There is some evidence that suggests that barriers are breeched when the host is dormant and unable to respond.

3. Construction of the cDNA libraries is currently underway.

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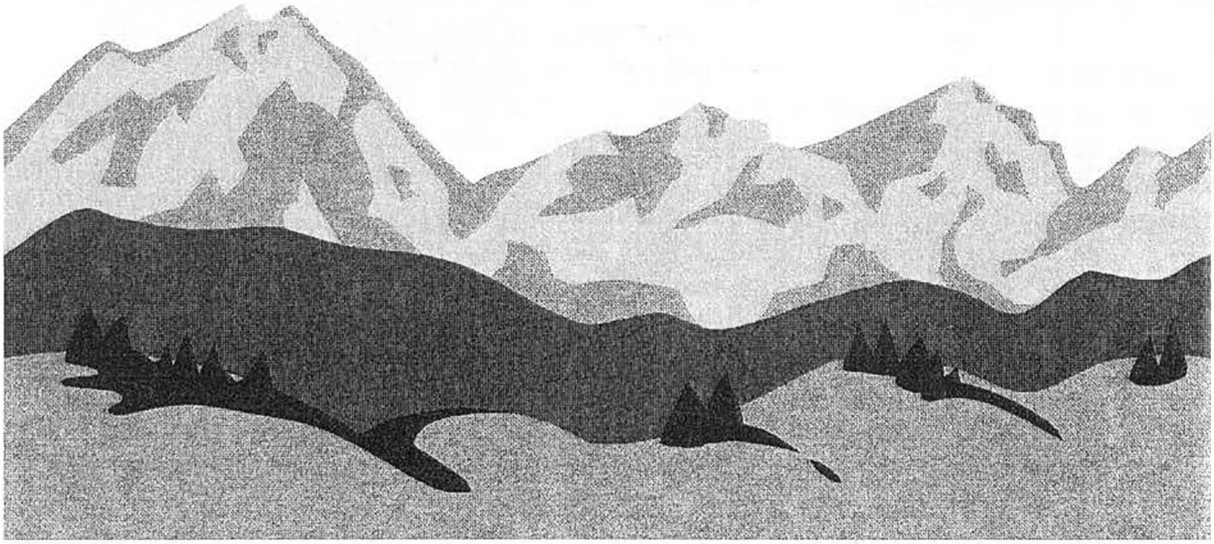
Acknowledgements

Financial and in-kind support for this project is provided by Forest Renewal British Columbia (Lands and Resources Research -Tree Genetics component), the Forest Biotechnology Network of the Canadian Forest Service, Natural Resources Canada, the BCMOF, Research Branch, TimberWest Forest Corp., and Western Forest Products. Operational and technical support is provided by CFS staff at the Pacific Forestry Centre and BCMOF staff at the Cowichan Lake Research Station.

Field Trip



WIFDWC/WFIWC Field Trip

Dave Johnson and Roy Mask

The field trip included visits to Vail, CO and to nearby Dillon Reservoir. Foci for the field trip were on management activities related to dwarf mistletoe and mountain pine beetle in lodgepole pine. The field trip was well attended, with approximately 180 participants.

The theme of the Vail leg was, "Mountain Pine Beetle, Changing the Face of Vail Valley's Lodgepole Pine Forests". Guest speakers included John Grieve, High Country Area Forester, Colorado State Forest Service; Dave Ozawa, Winter Recreation Forester, Holy Cross RD, White River NF; Bill Wood, District Ranger, Holy Cross RD, White River NF; Dave VanNorman, Timber Management Forester, East Zone, White River NF; Patrick Hammel, Environmental Health Specialist, Town of Vail and Tom Eager, Entomologist and Roy Mask, Leader, Region 2 Forest Health Management, Gunnison Service Center.

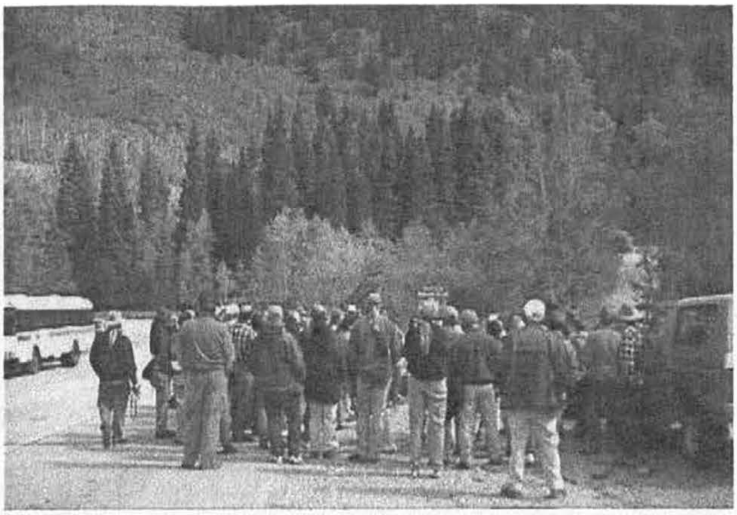
Sites visited in the Vail area included: 1) a mountain pine beetle sanitation timber sale located immediately uphill from the Holy Cross Ranger District office; 2) the Gerald Ford Park area which provided a panoramic view of MPB activity in and around Vail; and 3) Gore Creek Campground, an area adjoining the Eagles Nest Wilderness that has sustained significant impacts from MPB since 1996. Topics of discussion included multi-agency partnerships, MPB treatment methods, stand susceptibility, MPB impacts (economic and otherwise) and management issues unique to the Vail setting (e.g. world-class ski resorts and real estate markets, avalanche and wildfire dangers and limited access).

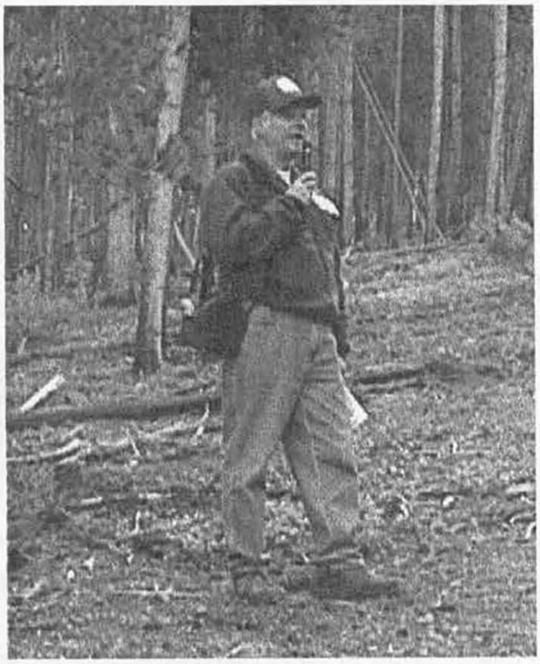
The theme of the Dillon Reservoir portion of the field trip was "Dwarf Mistletoe in The Dillon Reservoir Area – Past Management and Opportunities". This session was led by Dave Johnson and Bill Schaupp of the Lakewood Service Center, USDA Forest Service. Discussion focused on vegetation management on National Forest System lands surrounding the Reservoir, primarily on developed sites where lodgepole pine dwarf mistletoe is a major concern in long-term management of the vegetation. Sites visited included 1) Sapphire Point Overlook, which provided an overview of the entire Reservoir and surrounding Forest, including the Upper Blue Stewardship Project area; 2) a remnant ponderosa pine stand threatened by MPB and a discussion of tactics to protect it; and 3) Heaton Bay Campground and vegetation management strategies to reduce impacts from dwarf mistletoe and MPB.

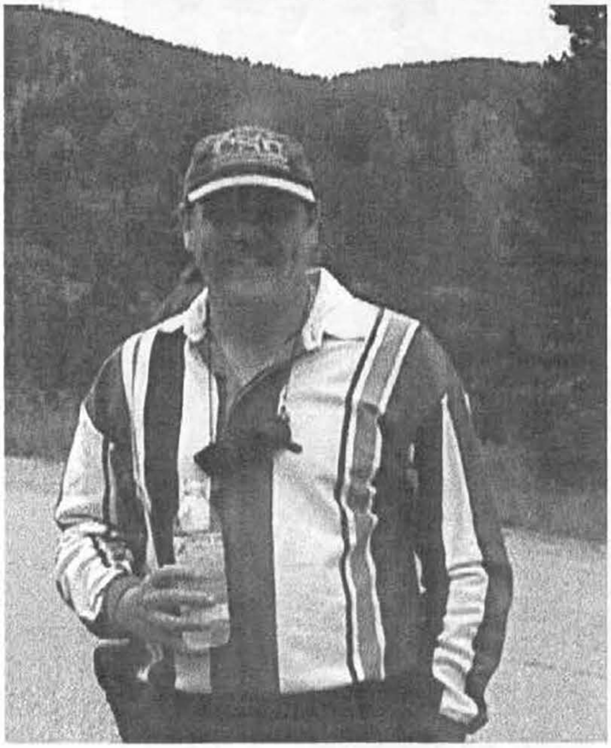
Additional field-related treats were the two self-guided tours:

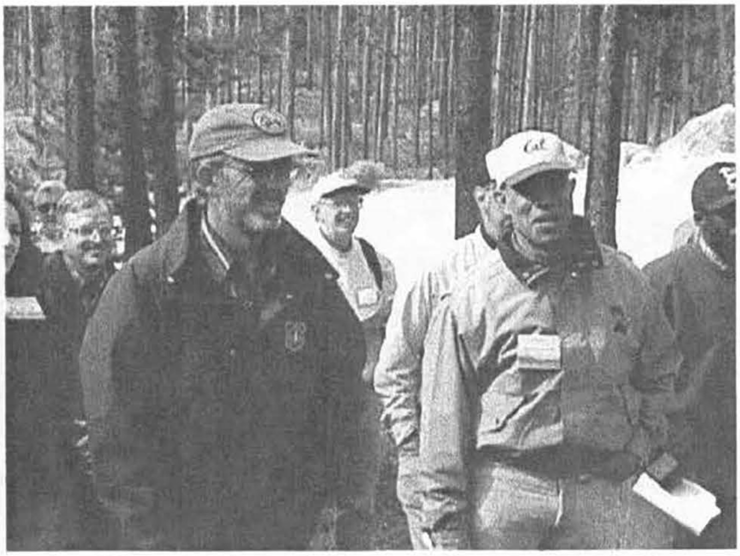
1) Walking - subalpine fir decline (caused by *Armillaria*, *Dryocoetes confusus* and possibly other organisms) in stands immediately adjoining ski runs, just uphill from the conference facility.

2) Driving – several sites referenced by mile marker number located along Interstate 70 between the conference site and Denver.



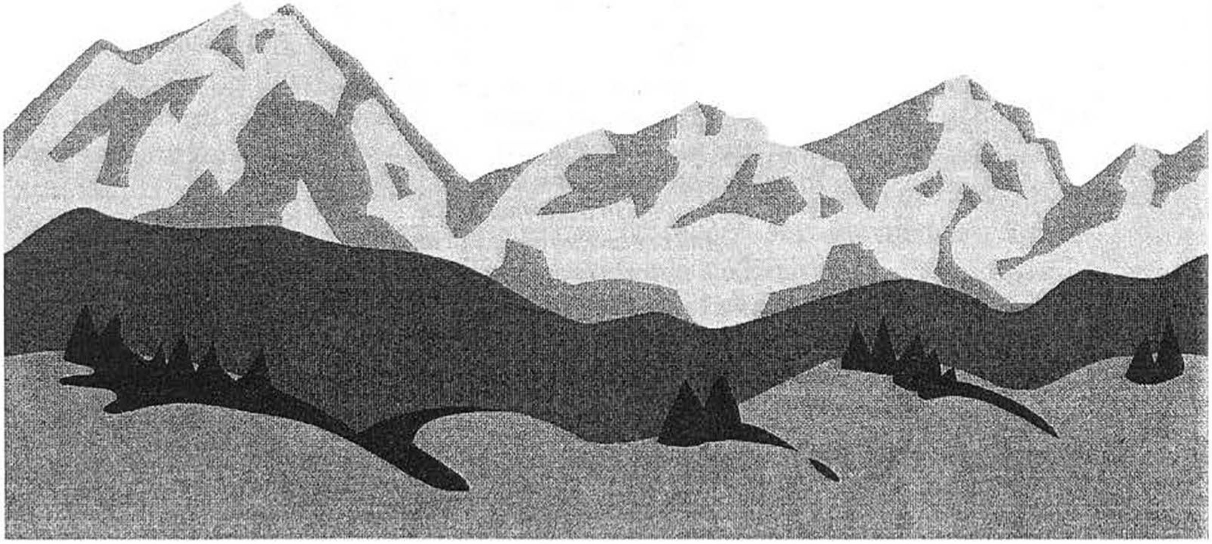






WFIWC

Founders Award Presentation

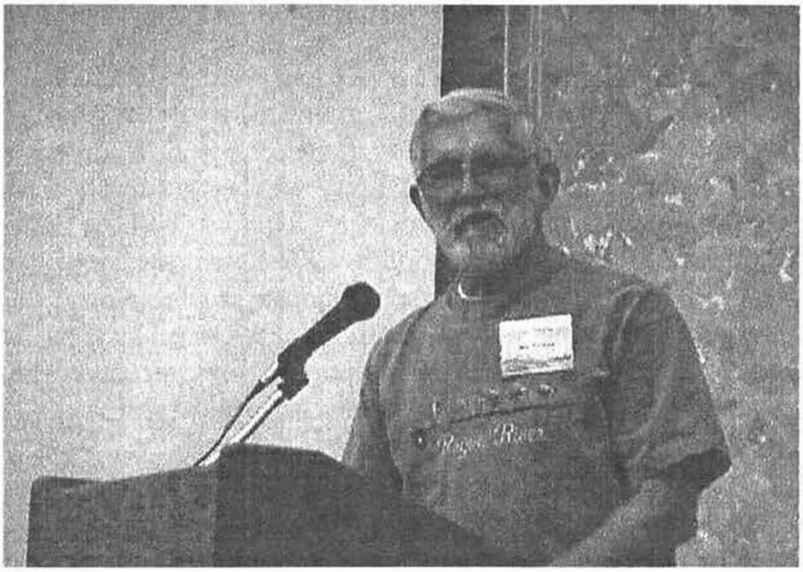


The Calf Path

One day through the primeval wood
A calf walked home as good calves should;
But made a trail all bent askew,
A crooked trail as calves all do,
Since then three hundred years have fled
And I infer the calf is dead.
But still he left behind his trail,
And thereby hangs my moral tale.
The trail was taken up next day
By a lone dog that passed that way;
And then a wise bellweather sheep
Pursued the trail o'er vale and steep
And drew the flock behind him, too;
As good bellweathers always do.
And from that day, o'er hill and glade
Through those old woods a path was made.
And many a man wound in and out,
And dodged and turned and bent about,
And uttered words of righteous wrath
Because 'twas such a crooked path;
But still they follow – do not laugh –
The first migrations of that calf.
This forest lane became a road,
There many a horse with his load
Toiled on beneath a burning sun
And traveled some three miles in one.
And thus a century and a half
They trod the footsteps of that calf.
The years passed on in swiftness fleet;
The road became a village street;
And this, before men were aware,
A city's crowded thoroughfare,
And men two centuries and a half
Trod in the footsteps of that calf.
A hundred thousand men were led
By one calf near three centuries dead.
For men are prone to go it blind
Along the calf paths of the mind
And work away from sun to sun
To do what other men have done
They follow in the beaten track
And out and in, and forth and back,
And still their devious course pursue.
To keep the path a sacred grove
Along which all their lives they move
But how the wise old wood gods laugh
Who saw the first primeval calf.

Founders Award Address

Malcolm M. Furniss, University of Idaho, Moscow, ID



My response as the recipient of the 1998 Founders award was largely biographical with emphasis on my studies involving bark beetle – fungus associations, in keeping with the theme of this joint meeting of entomologists and pathologists. In doing so, I sought to emphasize the circumstances and people as they related to my career as a forest entomologist beginning with the precise middle of the 20th century and continuing to the present. Regretfully, for the Proceedings I must omit many anecdotes that have enlivened my travels and associations.

I was born June 17, 1926 at Branchville, NJ, the last of seven children of Clinton C. and Ruth Watts Furniss. The oldest, Robert L. Furniss (1907 – 1980), was a founder of the WFIWC. My first recollections are of Waverly, Tioga Co., NY where I resided until graduating from high school in 1944. I took naturally to exploring the woodlots and rivers of that rural locality, developing an enduring love for the outdoors and related activities.

In October 1944, my mother and I moved to Berkeley, CA where she resumed employment as a registered nurse. On Jan. 20, 1945, I entered the Army Air Corps at Camp Beal as an aviation cadet and was stationed successively at Truax Field, Biloxi, Miss., Roswell Air Field, Roswell, NM (the first atomic bomb was detonated at White Sands during that time), and Truax Air Field, Madison, Wisc. However, termination of WW II prevented me from completing that training and I was discharged on Nov. 8, 1945.

The war had begun when I was 15 and, until my discharge, I had not thought about a University education or the choice of an occupation. But forestry seemed interesting so I enrolled with the aid of the "GI Bill" at University of California in the spring term of 1946. I had never taken school seriously and had several deficiencies; however, I was admitted as a Special Student. My lack of studying ability resulted in receiving an "F" from Dr. Pappenfus in Botany 12, a 4-unit course. As it turned out, that was the best medicine I could have had. I discovered that I did not like failure. I also realized another trait: I hate doing the same task twice. So, that fall, I enrolled in a 5-unit Botany course (different teacher and content). I received an "A" and I was off to the races. I thoroughly enjoyed those 4 years at Cal. I graduated in January 1950.

Employment, 1950 -1954

. By now I was married to Irene M. Drummond and we had two children (Richard and Carolyn). We were still living in Richmond in 4-apartment housing constructed during the war for Kaiser shipyard workers. I continued for a time working as a chemist's assistant at the California Ink Co. in west Berkeley, formulating paint, as I had done throughout my enrollment at Cal.

In June, I was hired by Paul Keen at the Berkeley Forest Insect Lab, Bureau of Entomology & Plant Quarantine, as a temporary employee at $240/ month to survey beetle-killed trees in the Sierra Nevada Mtns. The Forest Insect Lab was located in the basement of Walter Mulford Hall on the campus. The staff included John M. Miller (retired) who had graduated from Stanford in 1907 (5 years after creation of the Div. of Forest Insect Investigations, USDA) and who was hired by A.D. Hopkins, first Chief of FII after its creation in 1902. Others, besides Keen, were Ralph C.Hall, George R Struble, and Jack W. Bongberg who was in charge of surveys and development of the California Risk Rating system. (Both Boyd Wickman and I were assigned that work at different times after Jack transferred to Albuquerque). However, everyone on the staff participated in varying degree in all three functions of the laboratory: Research, Surveys and Control Supervision.

In 1953, the Bureau of Entomology and Plant Quarantine was dissolved and those of us in the Div. of Forest Insect Investigations were transferred to the Forest Service (Calif. Forest & Range Experiment Station), but still in the same building.

Before long, responsibility for surveys and control supervision were transferred from the Experiment Station to the administrative Regions. I believe that had lasting adverse consequences. Plots that had existed for decades ceased to be resurveyed. Perhaps more importantly, the BE&PQ was an agency with no direct ties to resource management (a neutral entity). We enjoyed very friendly and close relationships with all agencies: FS, NPS, BIA, BLM, State Forestry Departments, and especially the many private forestry companies and organizations such as Weyerhaeuser, Collins Pine, Fruit Growers Supply, Western Pine Assn., etc. For example, Paul Keen and Ernie Kolbe, later head of Western Pine Assn., were roommates during their bachelor days; and Weyerhaeuser Co. honored Paul by commissioning a painting of him beside a beetle-killed tree that was published in national magazines. Anyway, after the transfer to the FS, we could no longer be as close to industry as we had been and I believe that cost us. Furthermore, the administrative separation and physical isolation of personnel in Research and Surveys disrupted the mentoring such as had benefited me earlier. Now, the transfer and application of research that had occurred so routinely seemed less so, and varied with the attitudes of individuals on both sides.......But I stray from my task.

During the summers, my family lived among the forest in wall tents, first at Blacks Mtn. Experimental Forest, then at Hat Cr. Field Base, both in Lassen Co., northeastern Calif. We lost only a day to travel going out from Berkeley in June and returning in September. We had no phone service. Lightning storms were common in afternoons and Irene would take the kids away from the big ponderosa pine that towered over the tents.

Every two weeks, we would take our old DeSoto on a grocery run to Susanville, dodging rocks and outcrops on the so-called "Pittville Highway." Once on the return, still 20 miles from camp on a sweltering day, we had two blowouts. Fortunately, someone besides us was travelling that wayward road and took us and our melting provisions on to camp.

One of my jobs during this time was to survey bark beetle hazard on 120,000 ac of remaining old growth pine on the Lassen N.F. to prioritize areas for "sanitation-salvage" logging (removal of high risk trees). George Downing worked for me one summer

Ogden, UT, October 1954 – May 1955.

I transferred to the Intermountain Forest & Range Experiment Station at Ogden, UT in October 1954. Jim (James C.) Evenden, who had set up the Coeur d'Alene Forest Insect Lab in 1918, was my distant supervisor for a short time before Don (Donald D.) Parker took over as Division Chief at Ogden.

By then, less than a year under the Forest Service and conscious of having only a BS Forestry degree, I was getting nervous that I might be reassigned to work involving other than forest insects. However, I had acquired 12 units of entomology, sufficient to meet the Civil Service requirement for classification as an Entomologist.

So, when Evenden came to Ogden on his first visit we invited him to dinner (Irene can cook as many of you know!). Well, Jim enjoyed the meal, saying to Irene, while patting his stomach: "Those rolls really hit the spot." His mellow mood lasted into the evening and I found occasion to express my concern and wondered if it were possible to be reclassified from Forester to Entomologist. He said that he would look into it and he did and I was. It sort of reminded me of the sign on Jim Kimmey's desk in Ogden: "Yesterday, I couldn't spell Pathologist and today I are one."

Boise, ID, 1955 - 1963

Coinciding with my transfer to Ogden was a spruce budworm infestation on one million acres of five national forests in southern Idaho and plans were underway to spray it with DDT (1 lb/ gal of diesel oil). That, plus a recent outbreak of pine butterfly on the Boise N.F., led to the decision to transfer me to Boise in May 1955. I couldn't have been happier; here was a state possessing everything that I enjoy.

That summer, I was in charge of the entomological aspects of the project that is still the largest in Idaho. Project personnel were divided into two activities, mine involving daily monitoring of larval development to time spraying just prior to pupation, and spray operations involving production measured by thousands of acres sprayed. Because no spray unit could be released for spraying without my authorization, there was constant pressure from the other side. People were up before dawn seven days a week. Everybody was tired. Thus, when Jim (James A.) Beal, Chief of Forest Insect Research, Wash. DC, came through Boise en-route to visit me at my location in Idaho City my counterpart in operations at the Boise Forest Supervisor's office gave him an ear full. After his arrival in Idaho City and after a libation, Jim smiled and said that I must be doing my job because he had gotten complaints on his stop in Boise. That was a great boost for my morale!

In the following year, I was assigned to study the Douglas-fir beetle, which at the time was rated as the #1 bark beetle problem in the northern Rocky Mtns. When roads opened that spring, I looked for a suitable study area. I remember my elation as I crossed Lick Cr. summit east of McCall, then down into the Salmon River drainage. This place had a mystical attraction. By chance, I located a group of infested trees on an alluvial bench near Camp Creek on the Krassel Ranger District. The trees were on a parcel of land homesteaded by Bill Darling in the 1920's. We subsequently became good friends. His education had ended in grade school but his intellect and memory of events and details was seldomly equaled among others whom I have come to know. Those trees provided my first data on a study of sampling methods involving distribution and density of galleries and broods in standing and downed trees.

By further chance, a building (photo), dating to the CCC days (pre-WWII) was still at Camp Cr. We refurbished it and it served as our summer residence from 1956 to 1962. Finally, after the 1962 season, our children, now teen-agers, declared that they wanted to spend summers in town playing baseball and doing other things. So, after 11 years camped out summers among the forest, the cohesion of my family and my research ended.

Moscow, ID 1963-1982

In May 1963, at age 37, I transferred to the new Forestry Sciences Lab at Moscow and enrolled part time at U. Idaho. My MSc thesis dealt with a previously unstudied geometrid on curlleaf Cercocarpus in Owyhee Co. Bill Barr was my major professor. I graduated in May 1966.

Throughout this time and thereafter, I continued studying many aspects of the Douglas-fir beetle and other bark beetles and shrub insects. The identification of the first bark beetle pheromones in 1966 (*Ips* in Calif.) was followed rapidly by other such discoveries including the DFB aggregative pheromone, frontalin. I became involved with field testing frontalin in 1970 at the "suggestion" of INT Director, Joe Pechanec. We were in a DC-3 airplane viewing an outbreak of DFB on the Boise N.F. He, Assistant Dir. Chuck Wellner and I were crowded at a side window. Over the din of the motors, he looked straight at me and asked: "Shouldn't we be studying pheromones?"....Not waiting for my answer, he said, "Can we afford not to?"

Thus, I embarked on field tests that same year that determined that alpha pinene in tree resin synergized the attraction of frontalin. In 1971, I discovered that another DFB pheromone, (MCH), identified by Julius Rudinsky (OSU),was an anti-attractant, functioning to turn off attraction after a male has located a female. During the next 10 years, I was helped by many persons (shown in resulting publications, including Mark McGreggor and Ladd Livingston) in developing MCH for aerial application to *temporarily* susceptible trees (e.g., windthrown, snow-broken) to *prevent* release of a DFB population that subsequently kills live trees.

During these years, I also travelled several times to Mexico doing fieldwork, often accompanied by David Cibrian of the University of Chapingo (and once by Frank Hawksworth, the mistletoe taxonomist). Notable accomplishments included discovery of the DFB in that country in 1974 and studies of *Dendroctonus rhizophagus* that resulted in removing it from synonymy with *D. valens*. I also tested various pheromones in Alaska in cooperation with Bruce Baker and Richard (Skeeter) Werner, involving the spruce beetle and *D. simplex*.

Moscow, ID 1982 – present.

In April 1982, I retired as Project Leader of a research work unit entitled: Insects of Forest Trees and Wildland Shrubs the Northern Rocky Mtns. That ended the continuous presence in Idaho of forest insect research by USDA forest entomologists that began with Jim (James C.) Evenden at Coeur d'Alene in 1918 when he returned from WW I as a Capt. in the Artillery.

Upon my "retirement" I became affiliated with the Department of Entomology at U. Idaho, continuing to the present.

In the intervening years, I demonstrated in Norway (with Erik Christiansen and Halvor Solheim) the way in which the pathogenic blue stain fungus, *Ophiostoma polonicum* is vectored by *Ips typographus* and in Idaho: *O. Ips* by *Ips pini* (with Al Harvey). In both instances, ascospores were shown by SEM to be carried in pits on the prothorax or elytra. The notion that this might be so was due to Ladd Livingston's earlier discovery of similar spores in pits on the head of *Scolytus ventralis*.

Other important work was surveying with J.B. "Ding" Johnson and Sandy Kegley the Scolytidae species that occur in the four Northwest States. And completion of a Field Guide to the Bark Beetles of Idaho (114 species) that has been submitted for publication by the Entomological Society of America as a Thomas Say Monograph.

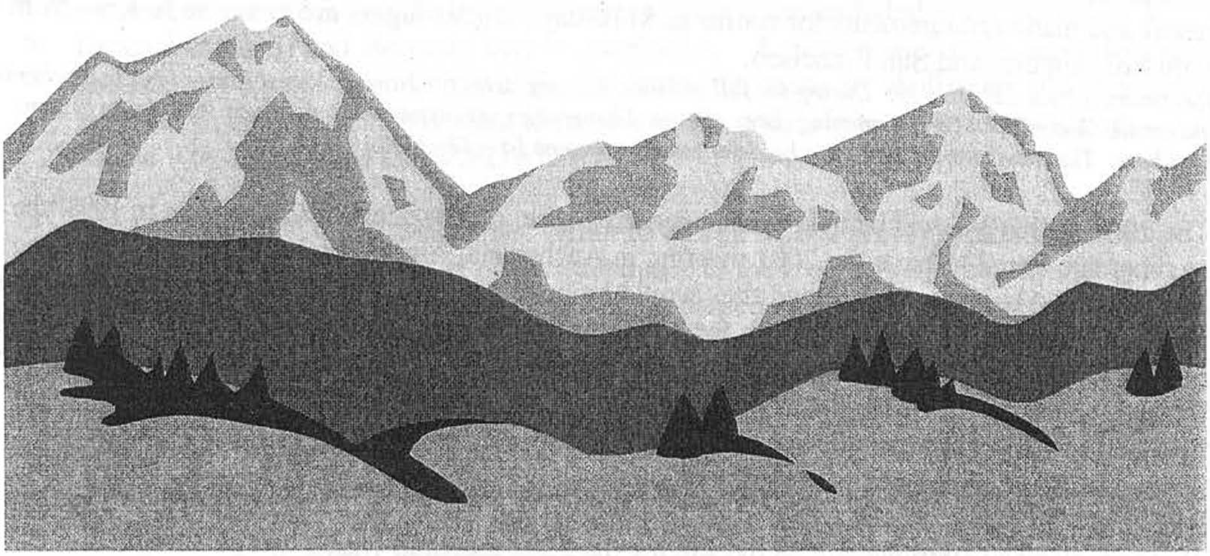
Also in the last decade, I have studied two insects on Alaskan willows: a leaf miner infesting vast areas of the interior (Submitted for the Can. Entomologist John Borden Memorial issue) and the willow bark beetle, *Trypophloeus striatulus* (Mann.). These studies resulted from my conversation with Ed Holsten (Anchorage) at the Penticton WFIWC during which he invited me to fly on the annual aerial surveys in 1992-3, resulting in field studies in 1996-7.

Finale.

I especially wish to thank Sandy (Gast) Kegley for nominating me, for her eloquent introduction and for her friendship. My sincere thanks also to the many, some mentioned herein, who contributed to my career in differing ways and without whose help and influence there would be no basis for my receiving this award.

WIFDWC

Minutes of the 1999 Business Meeting
Committee Reports
Region 2 Report
Past Meeting Information
Honorary Life Members



WIFDWC Business Meeting

Submitted by Ellen Michaels Goheen

WIFDWC Chairman Fred Baker called the meeting to order at 10:35 am, Friday, September 17, 1999. Twenty-five members were present.

Hearty thanks were extended to Dave Johnson and all of the people from Colorado and Region 2 who helped arrange this joint meeting of WIFDWC and WFIWC. 192 participants registered for the meeting, including 35 graduate students and retirees.

The minutes of the 1998 WIFDWC meeting held in Reno, Nevada, were approved as written.

John Schwandt, WIFDWC Treasurer, gave a brief Treasurer's Report. The final balance in the WIFDWC account at the end of 1998 was $2,165.95. John and Dave Johnson were still sorting through the bills for this meeting; a complete Treasurer's Report will be included in the proceedings. An agreement was made with the WFIWC Executive Committee to send the proceedings to meeting attendees and the WIFDWC Honorary Life Members.

Future Meetings

The WIFDWC railroad announced that the nominees for officers for the year 2000 meeting were: Chairman: Bill Jacobi, Secretary: Pete Angwin, and Program Chair: Sue Hagle. The selections were approved, seconded, and passed by unanimous vote. John Schwandt will continue in his position as Treasurer.

The 2000 WIFDWC will be held August 20 – 25, at the Outrigger Waikaloa Beach Resort, 15 miles north of Kona on the island of Hawaii. The meeting theme will be exotics and introduced organisms. Jerry Beatty is handling local arrangements. He has signed a letter of intent with the resort and made arrangements for rooms at $110/day. Direct flights are available to Kona from both Los Angeles and San Francisco.
(Secretary's Note 12/01/1999: During the fall of 1999, meeting dates for Hawaii were discussed by the membership via email. A conflict with the opening dates of some Universities was expected to preclude attendance by some members. The membership agreed to hold the meeting August 14 – 18, 2000.)

The 2001 WIFDWC will be held in the Monterey area, on the coast of California. In 1998, the membership voted to have the 2001 meeting in Anchorage, Alaska; however, during the spring of 1999, the Alaska group decided they would be unable to arrange the meeting. California was also nominated as a meeting location for 2001 during the 1998 meeting but lost to Anchorage by one vote. The Californians offered again to arrange the 2001 meeting and the membership voted to accept their offer. Susan Frankel will head up the local arrangements. There will be opportunities to visit field sites with pitch canker and tan oak decline. The membership suggested September as a meeting time.

Victoria, British Columbia will be the site for the 2002 meeting, which will be the 50th WIFDWC. This has historical significance because the first and 25th WIFDWC meetings were also held in Victoria. John Muir is beginning to work on local arrangements. The meeting will most likely be held during August.

Old Business

Rona Sturrock posed several questions to the members regarding confusion that the WIFDWC Secretaries have encountered in recent years.

> Membership: The mailing list includes scientists who have attended recent meetings but are visitors from other countries. Because members are considered to be those "individuals who are engaged in forest pathology-related endeavors in western North America" are these visitors now members and do their names remain on the mailing list for five years? After discussion it was agreed that "visitors" who attend meetings receive the proceedings of the meetings they attend, that their names remain on the member list for no longer than five years, and that the Secretary will decide if those "visitors" will receive information related to future meetings.
>
> Honorary Life Membership: There is some confusion regarding how Honorary Life Membership (HLM) in WIFDWC is bestowed. Rona brought up that John Hart, Eugene Van Arsdel, and Max Ollieu are all recent retirees whose names are on the membership list. Ed Wood's name was also offered as a potential HLM. The members put these names to a vote. In the process, a discussion took place regarding what "active" membership in WIFDWC means. A motion was made, seconded, and passed to give HLM status to John Hart, Eugene Van Arsdel, and Ed Wood. A motion was made, seconded, and passed to table further designation of HLM status until the members agree on a set of criteria. Fred Baker asked John Laut to form a committee that will define HLM criteria and report back to the members at the next WIFDWC.
>
> Article 9 of the WIFDWC Bylaws includes that the Secretary annually query the HLMs to see if they want to receive the proceedings. This is not included in the Secretary's Duties (Article 3) and therefore may be overlooked. A motion was made, seconded, and unanimously agreed upon to move the statement "the secretary shall query the honorary members to determine if they want to receive a free copy of the proceedings" from Article 9 to Article 3 of the WIFDWC Bylaws.
>
> HLM Registration and Proceedings: What to charge HLMs for registration fees and whether or not to charge HLM not in attendance at the meetings for proceedings was discussed. A motion was made, seconded, and passed to amend the bylaws to include in Article 7 the statement that "registration will be reduced by half, if possible, for graduate students and Honorary Life Members. It will be at the discretion of the WIFDWC Executive Committee for each meeting to offer a further reduction in fees to graduate students and Honorary Life Members and to offer reduced fees to others such as retired professionals and visitors". *It should be noted that Article 3 of the Bylaws still needs to be amended to list this as a decision to be made by the Executive Committee.* No change in policy regarding providing HLMs with a free copy of the proceedings was made.

Maintaining Membership Lists: It is the duty of the Secretary to maintain a current WIFDWC mailing list. This can be challenging as the office of the Secretary changes from year to year. Despite these challenges, it was agreed that the Secretary should continue to maintain the mailing list. Hopefully the list will be easier to maintain as database software stabilizes, it becomes easier to move the information to different software platforms, and the use of email for communication among members increases.

Assisting Outside Speakers: While there was a resolution made in 1995 to allow the Executive Committee of each WIFDWC to decide who and how may speakers can be assisted with WIFDWC funds to cover meeting and travel costs, there has been recent discussion of this issue. It was agreed to amend the Bylaws to include a statement in Article 3 indicating that the Executive Committee of each WIFDWC can decide who and how many outside speakers they want to invite to each meeting and that travel costs can be paid from conference registration fees.

There was much discussion on the subject of the Outstanding Achievement Award and specifically on the current status of the Award. In 1999 Fred Baker appointed Bart van der Kamp, Jim Byler, and Will Littke to the Outstanding Achievement Award Committee. They solicited nominations and nominations were received, however there was confusion as to when and how the criteria for selecting a recipient would be developed. Of the committee members, only Will Littke was in attendance at the 1999 meeting. Will reported that he assumed a discussion would take place in Breckenridge. It was decided that Bill Jacobi, WIFDWC Chairman 2000, write a letter to the committee to remind them that it is up to them to firm the criteria for the award, explain the criteria to the membership, develop a nomination process, design the award, and present the award if suitable nominations are made.

Committee Reports

Due to time constraints, Committee Reports were not given during the Business Meeting. Committee Reports will be included in the proceedings and available on the website.

New Business

The WIFDWC website was discussed. Thanks were extended to Judy Adams and her staff at Fort Collins for designing and maintaining the site. The membership agreed that having an electronic site for meeting information was very helpful. Ellen Goheen reported that since only a few members insisted on hardcopy mailing of meeting information, mailing costs were substantially reduced. Direct links to hotels and host city information were considered valuable. Judy Adams volunteered to continue to maintain a meeting website at Fort Collins. It was noted that this is not always an easy task and Judy's offer was greatly appreciated. The members did agree that they needed to be reminded of registration deadlines and wanted to be informed when substantial amounts of new information were placed on the website. Postcards and/or email messages were both considered appropriate ways to provide such updates.

The members then had a very lively discussion regarding placing meeting proceedings on the website. Some members believe that there is great value in having the information from the papers and posters presented at our meetings available to the public. Others expressed concern that putting proceedings on the web would change the tone of the proceedings, resulting in them being more formal, that people would be reluctant to report preliminary findings, and that contents would be misused. The potential to misuse information from hardcopies of proceedings that are in various libraries as well along with how well the disclaimer regarding contents of the proceedings is heeded were discussed. The decision was made to put the WIFDWC Committee Reports on the website as well as a synopsis of the meeting by the Chairman. A committee made up of Fred Baker, John Muir, and Judy Adams was formed to explore issues pertaining to web publishing.

Fred Baker volunteered to investigate the logistics and costs associated with publishing our past proceedings on a CD-ROM. He will report back at the next meeting.

Jane Taylor, Program Chairman for the 1999 meeting, expressed frustration regarding working with the entomologists to design an integrated program for this joint meeting. She brought up the question of whether we wanted to continue meeting with the entomologists in the future. The suggestion was made that we look at the programs of the joint meetings we have had with the entomologists and see if our meeting objectives are being met. A motion was made, seconded, and passed to consider this subject during the WIFDWC 2000 Business Meeting.

A brief discussion took place on the small number of members in attendance at this year's Business Meeting. The members decided to strongly suggest to the organizers of the 2000 WIFDWC that the Business Meeting be held at some time other than the last portion of the last day in hopes that participation will be stronger.

The meeting adjourned at 12:00 noon.

WIFDWC Treasurer's Report

Submitted by John Schwandt

The following is a summary of transactions for the 1999 Joint WIFDWC/WFIWC meeting in Breckenridge, Colorado.

There were a total of 192 registered for this joint meeting. This included 24 graduate students and 11 retirees. Although no official count was made, several folks brought spouses and children. The banquet and awards ceremony was attended by over 200 and over 160 people went on the field trip. Disease Committee meetings were well attended (dwarf mistletoe- 31; hazard tree-33; disease control-14; rusts-24; and root disease- 36).

TRANSACTION	AMOUNT	BALANCE
Balance reported at close of 46th meeting in Reno, Nevada		**3,884.21**
1998 WIFDWC (Reno, Nevada) adjustments		
Refunds of registrations	-180.00	3,704.21
Invited speakers expenses	-392.30	3,311.91
Printing of Proceedings	-969.38	2,342.53
Mailing Costs	-176.58	2,165.95
Final 1998 Balance		2,165.95
1999 Transactions		
Total Registration (minus refunds)	29,244.25	31,410.20
Meeting rooms, Banquet, etc including $1,000 deposit	-25,756.03	5,654.17
Deposit paid in 1998 ($500 each by Ento and Path accounts)	1,000.00	6,654.17
Field trip transportation	-1,750.00	4,904.17
AV equipment	-1,213.00	3,691.17
Mailing costs for announcements	-296.26	3,394.91
Breaks, Hospitality, misc expenses		3,394.91
Interest paid to account from 11/1/98 through 11/1/99	182.21	3,577.12
CURRENT BALANCE (as of 11/1/99) excluding Hazard tree balance		**3,577.12**
Printing and mailing costs for 1998 proceedings will be subtracted from this balance and reported in next year's proceedings.	???	

There is a balance of $2,417.13 in Hazard Tree conference funds ($124.20 was spent for AV equip at the joint insect and disease work conference) which is NOT included in the above balance.

WIFDWC Hazard Tree Committee Report

Submitted by John Pronos

The Hazard Tree Committee met for lunch at Breckenridge on September 14, 1999, with 35 people in attendance. We began our meeting by viewing a video provided by Rona Sturrock and produced in British Columbia. The video was made for the BC Wildlife Tree Committee to use in training their tree assessors to recognize hazardous trees, and it focused on decay fungi that contribute to tree failures.

We discussed providing Western U.S. hazard tree information on the Internet. The Forest Health Protection staff in St. Paul, through Joe O'Brien, has an excellent web site that includes hazard tree information, although much of it deals with hardwoods. Rather than create a new web site for western situations, we will first contact Joe it see if he is agreeable to adding information from the West that we would provide.

The main topic for this meeting was how our various members approach hazard tree training. Individuals from government agencies, universities and private industry answered the questions listed below. This information will be collated and provided to the members of the Committee.

HT Training Questions:

1. How often are courses offered and are they by request or scheduled in advance?
2. How long are the sessions and what proportion is indoor versus in the field?
3. Is there more than one type of training, e.g. basic and advanced?
4. What are the major topics covered in the sessions?
5. Do you include information on legal issues and rating systems?
6. What type of written materials are provided to the students?
7. What is the maximum class size?
8. Who do the students work for and what are their positions?
9. Do you include concessionaire employees in your sessions?
10. Are the courses taught by people from more than one agency?

One important discussion involved the situation with campground concessionaires and their responsibility for hazard tree management. Many National Forest recreation sites are now run by private concessionaires under special use permits. These permits normally make the permitee responsible for the identification and monitoring of hazard trees. Our concern is that concessionaire employees have not been trained to recognize defects that contribute to tree failures. A possible solution would be to add a training requirement for employees in the special use permit.

There have been two Hazard Tree Workshops – 1995 in Visalia, CA and 1998 in Hood River, OR. A third workshop may be held somewhere in Region 1 in 2001.

WIFDWC Disease Control Committee Meeting

Submitted by Robert L. James

The following people attended the Disease Control Committee breakfast and meeting: Robert James, Walt Thies, Will Littke, Joe Hudak, Jeri Lyn Harris, John Muir, John Browning, Susan Frankel, Borys Tkacz, Judy Adams, Andy Mason, and Greg DeNitto.

Walt Thies (USDA Forest Service, Corvallis, OR) began the meeting with a discussion of fertilizer application (to mediate root disease) research conducted on Champion International land. Potassium treatment has been done on 6000 acres. Limited research has been done and the extensive area on which applications have been made is way beyond the limited scope of efficacy trials. Past experience indicates that fertilization may work with *Armillaria* root disease and tests are being conducted to see if it will work with *Phellinus weirii* as well. Tests include application rates of 200 lbs. KCl and 200 lbs. of N per acre, plus untreated controls. The amount of root pathogen inoculum will be estimated. Analyses will include determination if seedlings on treated sites will have increased K in their foliage; also selected seedlings will be analyzed for increases in production of defensive chemicals.

Will Littke (Weyerhauser Company, Centralia, WA) discussed the current situation with Swiss needle cast on coastal Douglas-fir. He stated that there is a common misunderstanding about how much we know about the disease and biology of the pathogen. One study has involved paired trees, one of which was sprayed with chlorothalonil which provided good protection and disease control over a three year period. Affected trees often have lower levels of K, P, S, and Ca in their foliage, but not lower levels of N. He described field trials evaluating combinations of fertlization (with K, Ca, and S) with applications of chorothalonil. The trials were designed to evaluate infection levels on one and two-year-old needles. He described some "decline" symptoms on trees near the coast that look more like NaCl damage than Swiss needle cast. Affected trees displayed needles with tip burn symptoms and premature loss of up to about 50% of the foliage on some trees. Such problems were described as episodic events correlated with high wind speeds from the coast and exposure to high moisture influences. Many affected stands are composed of "off site" plantings of Douglas-fir. He concluded that something besides Swiss needle cast is occurring on coastal Douglas-fir, at least in the areas he surveyed. Extensive tree defoliation is not all due to the needle cast pathogen. He believes that most sources of Douglas-fir are not well adapted to the maritime influences near the coast. In particular, this species has low tolerance for salt which is readily deposited on foliage. He advocates that Douglas-fir should not be planted so near the coast as has been done in the past.

Littke also discussed aerial survey detection of standing dead trees associated with *Phellinus weirii* infection centers. The procedure, developed by Northwest Aerial Reconnaissance, provided about 90% accuracy in detected standing dead trees from high resolution aerial photography at a cost of about $2.00 per acre. A stand by stand readout is possible with this technology.

Joe Hudak (Washington State University, Puyallup, WA) discussed attempts to control Swiss needle cast with a trial of 18 different fungicides. The goal was to suppress disease and stop pseudothecial development. The test was started in the fall of 1998 and progressed throughout the winter. For some fungicides, only one application was made.

Jeri Lyn Harris (USDA Forest Service, Rapid City, SD) described problems with non-removal of dwarf mistletoe-infected seed trees in a timely manner after establishment of adequate understory regeneration, particularly on the Shoshone and Bighorn National Forests. Forest Service suppression funds were used to sanitize stands, but non-removal of infected overstory trees threatens new regeneration. It seems difficult to require recipients of suppression funds to finish the job by removing these trees before extensive infection of susceptible understory trees occurs.

Also from Region 2: The Bessey Nursery, located in Halsey, Nebraska, is participating in the nationwide project for developing alternatives to methyl bromide. Basamid (Dazomet), solarization and fallowing with tilling will be compared to methyl bromide as alternative treatments. Soil samples were tested at Oregon State University for pathogenic nematodes and soil-borne fungi. Eastern redcedar was sown in the treated beds and will be evaluated for emergence and growth vigor for the next two years along with soil samples to compare the best yield results of the various treatments.

John Muir (British Columbia Ministry of Forests) stated that needle cast by *Lophodermella concolor* has occurred at high levels during the last 10 years throughout interior lodgepole pine forests. He attributed this to wetter than normal spring and summer weather that has been occurring since 1985. He also stated that this may be a general situation with regards to foliage diseases and cited the *Dothistroma* problem on limber pine in eastern Montana as an example.

WIFDWC Dwarf Mistletoe Committee Report

Submitted by Robert Mathiasen and Jerry Beatty

I. TAXONOMY, HOSTS, AND DISTRIBUTION.

Our work on the taxonomic status of the shore pine dwarf mistletoe is continuing. More specimens of male plants of western hemlock dwarf mistletoe were collected from several populations throughout Oregon in early August and additional morphological measurements completed. We have started analysis of the shore pine dwarf mistletoe data. We are still considering the examination of molecular characters, but have not made any progress on this project thus far. (R. Mathiasen, Northern Arizona University, Flagstaff, AZ; E. Wass, Canadian Forest Service, PFC, Victoria, B.C.; S. Shamoun, Canadian Forest Service, PFC, Victoria, B.C., and D. Smith, Grand Forks, B.C.)

Further observations of the phenology of Hawksworth's dwarf mistletoe *(A. hawksworthii)* will be made in early October in Belize. (R. Mathiasen, Northern Arizona University, Flagstaff, AZ;)

Another population of the rare Honduran dwarf mistletoe (*A. hondurense*) was discovered in March near Lepaterique, Francisco Morazan, Honduras. This is only the third location reported for this dwarf mistletoe reported from Honduras, but specimens deposited at the Standley Herbarium at Zamorano, Honduras indicate it also occurs in Celaque National Park, Lempira in western Honduras. (R. Mathiasen, Northern Arizona University, Flagstaff, AZ; C. Parks, PNW Research Station, LaGrande, OR, and J. Beatty, WTCFID, Region 6, Sandy, OR)

Western dwarf mistletoe was found parasitizing planted Scots pine , CA (San Diego County). This is the first report of western dwarf mistletoe on Scots pine in California and only the second report of this dwarf mistletoe on this host. (J. Allison, San Bernadino NF, CA; B. Geils, RMRS, Flagstaff, AZ, and R. Mathiasen, Northern Arizona University, Flagstaff, AZ)

Guatemalan dwarf mistletoe (*Arceuthobim guatemalense*) was found in Department San Marcos, Guatemala in May, 1999. This confirms an earlier report by Dr. Ed Clark of this dwarf mistletoe in San Marcos. Collections were made and have been deposited at the Deaver Herbarium, Northern Arizona University, Flagstaff, AZ. (R. Mathiasen and S. Sesnie, Northern Arizona University, Flagstaff, AZ, and G. Dal Bosco, University of Del Valle, Guatemala City, Guatemala)

The golden dwarf mistletoe (*Arceuthobium aureum* ssp. *aureum*) was found commonly parasitizing *Pinus maximinoi* near La Cumbre, Department Baja Verapaz and near San Cristobal Verapaz, Department Alta Verapaz, Guatemala in May. This is the first report of golden dwarf on this host. Golden dwarf mistletoe induces large witches brooms on *Pinus maxinimoi* and some mortality from this host-parasite combination was observed near La Cumbre. Observations west of Chilasco, Guatemala indicate golden dwarf mistletoe does not parasitize *Pinus tecunumanii*. (R. Mathiasen and S. Sesnie, Northern Arizona University, Flagstaff, AZ, and J. Calderon, University of San Carlos, Guatemala City, Guatemala)

Male plants of *Arceuthobium globosum* ssp. *grandicaule* measuring over 74 cm in height were discovered on *Pinus rudis* in the Sierra de los Cuchumatanes near Chemal in western Guatemala in May. Female plants measuring over 66 cm in height were discoverd in the same populations. These represent the largest dwarf mistletoe plants discovered thus far in the Universe. Frank Hawksworths previous maximum plant height for this taxon was 70 cm. More trophy size dwarf mistletoe hunting in Guatemala is scheduled for March, 2000. (R. Mathiasen and S. Sesnie, Northern Arizona University, Flagstaff, AZ, and G. Dal Bosco, University of Del Valle, Guatemala City, Guatemala)

II. PHYSIOLOGY AND ANATOMY

We sampled a population of western hemlock dwarf mistletoe (A. tsugense ssp. tsugense) in the Wind River Experiment Forest, WA in June. Ten intermediate trees growing in open areas were destructively sampled and every branch on each tree was examined for mistletoe plants. All reproductively mature plants were sexed to determine the sex ratio of adult plants. The ratio was essentially 1:1749 females and 721 males. We plan to sample additional populations of western hemlock dwarf mistletoe in other locations using the same techniques. (R. Mathiasen, Northern Arizona University, Flagstaff, AZ; and D. Shaw, Wind River Canopy Crane Research Facility, Carson, WA)

III. LIFE CYCLES

IV. HOST-PARASITE RELATIONS

Remeasurements were conducted in 1999 on several plots in northern New Mexico designed to monitor the effects of prescribed burning on dwarf mistletoe infection levels in Southwestern ponderosa pine. Data are being compared to those from similar unburned PTIPS plots. (D. Conklin, FHP, Region 3, Albuquerque, NM)

Remeasurements were conducted in 1999 on two plots designed to monitor the spread and intensification of pinyon pine dwarf mistletoe. As expected, the intensification of this species is considerably slower than that of some other dwarf mistletoes. Overall, DMRs increased on about 7 percent of the infected pinyon pines during a five-year period, compared to about 35 percent of the infected ponderosa pines on our PTIPS plots. (D. Conklin, FHP, Region 3, Albuquerque, NM)

V. EFFECTS ON HOSTS

A series of permanent plots in black spruce stands in Minnesota was re-examined in 1998. *Arceuthobium pusillum* has killed almost all of the trees on these plots that were lightly infected in 1964. A manuscript is in preparation for Plant Disease. (F. Baker, Utah State University).

A dwarf mistletoe infested black spruce stand harvested in 1961 was revisited in 1998. Despite efforts to eliminate *A. pusillum* during and after harvesting, the parasite persisted at a low level. As new trees were infected, others were killed by dwarf mistletoe, with only a slight increase in the number of live, infected trees. In 1998, however, the number of trees had increased greatly on several of the plots, and the dwarf mistletoe had spread to new areas of the stand. It is unlikely that this stand will reach maturity with a volume sufficient for a commercial harvest. A manuscript for Plant Disease is in the final throes of preparation. (F. Baker, Utah State University).

VI. ECOLOGY

We have initiated a study to determine wildlife use of witches brooms induced by Douglas-fir dwarf mistletoe (*A. douglasii*) in northern Arizona. We hope to examine at least 100 infected and 100 uninfected trees and determine which wildlife species are utilizing brooms for nesting, resting, foraging and hiding sites and compare the use of infected trees with similar, but uninfected Douglas-fir. (S. Hedwall, C. Chambers, R. Mathiasen, Northern Arizona University, Flagstaff, AZ; ML. Fairweather, FHP, R3, Arizona; and C. Parks, PNW Research Station, LaGrande, OR)

I. GENETICS

VIII. MANAGEMENT

Project title: Biological Control of Dwarf Mistletoes
Project Leader: Dr. Simon Francis Shamoun- CFS Victoria, BC, Canada
Research Associates/Cooperators: Drs. Alan Thomson (CFS-Victoria); Zamir Punja (S.F.U.-Burnaby); Richard B. Smith (Ex-CFS- Research Scientist- Grand Forks); Mr. Ed Wass (CFS-Victoria); Bart van der Kamp (UBC- Vancouver); Ms. Carmen Oleskevich (CFS-Victoria); Ms. Shannon Deeks (M.Sc. candidate, SFU- Burnaby); and Mr. Tod Ramsfield (Ph.D. candidate-UBC, Vancouver); Stephan Zeglen (BC Min. of Forests- Nanaimo, BC); Fred Pattenden (BC Min. of Forests- Duncan Forest District- BC); Ed Senger (BC Min. of Forests-Lillooet- BC); George White (Riverside Forest Products- Williams Lake, BC); Kim Peel (Lignum Ltd., BC); Claire Treetheway - UBC Alex Fraser- Willams Lake, BC).

Research Objectives: The overall objective of the project is to survey and collect fungal hyperparasites and to investigate their potential use as biological control agents for dwarf mistletoes. Currently the focus of this research program is on biocontrol of western hemlock and lodgepole pine dwarf mistletoes.

Research Progress:

To date, 3 new records of fungal hyperparasites have been reported on western hemlock dwarf mistletoe, namely: *Colletotrichum gloeosporioides* and *Mitrula* sp. A new *Nectria* sp. was discovered on the swelling of the shore pine pathotype of *A. tsugense*.

From the diseased shoots, berries and swellings of western hemlock dwarf mistletoe,23 fungi were isolated, purified and identified, with a subsequent database of 208 isolates generated. (Computerized database is available from Dr. Simon Shamoun). All isolates are preserved under liquid nitrogen/or -80C for further research.

Fungi of special interest (potential biocontrol agents) that have been isolated includes *Colletotrichum gloeosporioides* (New record on western hemlock dwarf mistletoe), *Nectria neomacrospora,* and *Cylindrocarpon gillii*

Field trial- a field trial was initiated to evaluate the effect of fungal application on hemlock dwarf mistletoe *in situ* . Two selected hyperparasitic fungi namely *C. gloeosporioides* and *N. neomacrospora* (Anamorph *Cylindrocarpon cylindroides*) were used as candidate biocontrol agents. An inert carrier formulation was developed for the delivery of these two fungi. On September 04, 1997, the application of these two fungi on hemlock mistletoe were completed on a site near Duncan, BC. Observation at two months post-treatment showed high mistletoe shoot mortality for both fungal treatments. At 7.5 months post-treatment, there was shoot mortality up to 90% . Monitoring and data collection will continue for the next 3-5 years post-treatment. Future research focus is directed at treating the retention (border) trees in areas under partial cut harvesting systems.
Tissue Culture of western hemlock dwarf mistletoe- A novel protocol for *in vitro* tissue culture of western hemlock dwarf mistletoe was successfully produced callus for the first time with this species. Research efforts underway are to develop an *in vitro* rapid method for screening the potential candidate hyperparasitic fungi and their use as biocontrol agents.

Publications/Conferences- The following publications and conference attendance were achieved: 1) Mycoflora associates of western hemlock dwarf mistletoe plants and swellings collected from southern Vancouver Island, British Columbia. Can. Journal of Plant Disease Survey (In press); 2) Tissue culture of parasitic plants- methods and application in agriculture and forestry- In Vitro Cell Dev. Biol. Plant (In press); 3) The occurrence and assessment of fungal parasites as potential biological control agents of western hemlock dwarf mistletoe (Oral presentation at the Joint meeting of the American and Canadian Phytopathological Societies (APS/CPS) at Montreal, Quebec, Canada, August 07-11, 1999); 4) Histopathological examination of western hemlock dwarf mistletoe infected with potential biocontrol fungi (Poster presentation at the APS/CPS Montreal, August 07-11, 1999); 5) Fungal parasites of lodgepole pine dwarf mistletoe in British Columbia (Poster presentation at the APS/CPS at Montreal, August 07-11, 1999).

In 1997, a new project was initiated on biological control of lodgepole pine dwarf mistletoe. Mr. Tod Ramsfield - Ph.D. Candidate at the Dept. of Forest Science - UBC is working under the directions of Drs. Bart van der Kamp (Professor & Head, Dept. of Forest Sciences, UBC) and Simon Shamoun (Research Scientist & Adjunct Associate Professor, CFS/PFC Victoria, and Dept. of Forest Sciences, UBC). To date, there has been more than 30 sites selected throughout BC. Diseased samples from shoots, berries and swellings of lodgepole pPine dwarf mistletoe have been collected and currently hyperparasictic fungi have been isolated and preserved for further research. Future proposed work will focus on using *Colletotrichum gloeosporioides* as an inundative biological control agent for lodgepole pine dwarf mistletoe. There are two major components to field research, the first to study the effects of Colletotrichum *gloeosporioides* on dwarf mistletoe and the second is to stimate dwarf mistletoe response to shoot removal. In addition to these, there are two ongoing experiments underway: 1) the effect of *Caliciopsis arceuthobii* and its effect on lodgepole pine dwarf mistletoe; and 2) In Fall, 1998, 255 lodgepole pine seedlings were inoculated with *Arceuthobium americanum* seeds collected from Lytton, BC.

These infected trees with dwarf mistletoe will be used as experimental units for testing the efficacy and biology of the potential biocontrol agent *Colletotrichum gloeoporioides*.

IX. SURVEYS

Mountain Hemlock Dwarf Mistletoe: Strategic Plan for Extensive Survey, Pacific Northwest Region

Diane Hildebrand and Jerome Beatty

Mountain Hemlock Dwarf Mistletoe, *Arceuthobium tsugense* subsp. *mertensianae,* is a component 4 taxon, under the Survey & Manage guidelines of the Northwest Forest Plan, as revised in July 1995. This means that the Pacific Northwest Region is required to "conduct general regional surveys" for mountain hemlock dwarf mistletoe (MHDM) in the State of Washington.

The Survey

Forest Insects & Diseases (FID) in the Regional Office, Portland, Oregon, and the Westside Service Center, Sandy, Oregon, began the survey for MHDM in July 1995. The survey included revisiting documented sitings, visiting old timber inventory plots that had dwarf mistletoe recorded on mountain hemlock, and by visual reconnaissance from Forest roads. Since 1998, surveys also use information from the new Continuous Vegetation Survey (CVS). Survey information gathered includes the map location of populations of MHDM, host tree species, intensity of infection, and other points of interest. For newly recorded population locations, voucher specimens are collected and sent to Dr. Robert Mathiasen for confirmation and storage in the Dwarf Mistletoe Herbarium at the Rocky Mountain Forest & Range Experiment Station in Flagstaff, Arizona.

The old timber inventory system began to include dwarf mistletoe rating information for major tree species as early as 1972 in Oregon and Washington. The years of timber inventory actually used in the data summary for the "original" hemlock dwarf mistletoe report (R6-95-02, Arceuthobium tsugense, Hemlock Dwarf Mistletoe, A Species of Special Concern?) were 1974 through 1987. We found the dwarf mistletoe information in the old timber inventory not to be particularly reliable.

Using the CVS data, we are finding the dwarf mistletoe information to be much more reliable. Differences between the old timber inventory and the new CVS include better training of surveyors with regard to insects and diseases, and inclusion of accuracy of insect and disease scoring in the quality control evaluation of survey crews.

We have used CVS data to find new populations of MHDM in Washington. Because of difficult physical access to most of the CVS plots in the mountain hemlock zone, we are not attempting to systematically check the accuracy of dwarf mistletoe reporting in CVS. The CVS data could be used to obtain reasonable estimates of incidence of dwarf mistletoe on mountain hemlock, especially given that the CVS grid is designed to make such estimates.

Information on locations, hosts, and extent of populations of MHDM will help FID specialists recommend the appropriate level of management for this taxon.

Accomplishments

FID began the survey in July 1995 on the Gifford Pinchot, Mt. Baker-Snoqualmie, and Olympic National Forests. Results from the 1995 survey are reported in the FID publication R6-97-01, Mountain Hemlock Dwarf Mistletoe 1995 General Regional Survey in Washington, January 1997. Dr. Robert Mathiasen (volunteer), Jerome Beatty (FID, Westside Service Center), and Diane Hildebrand (FID, RO) found one population of MHDM on the east side of Mt. St. Helens National Volcanic Monument. They found MHDM in six different areas on the Mt. Baker-Snoqualmie National Forest, and one population near Three Peaks on the Olympic National Forest.

In 1997, Mathiasen, Beatty, and Hildebrand continued the survey, focusing on east side stands of mountain hemlock. They found larch dwarf mistletoe (*Arceuthobium laricis*) infecting mountain hemlock south of Rimrock Lake (T. 13N., R. 13E, S. 19) on the Wenatchee National Forest. They did not find MHDM.

In 1998, Beatty and Hildebrand surveyed in the vicinity of the new CVS plots on the Gifford Pinchot National Forest. MHDM was growing on mountain hemlock and sub-alpine fir, and rarely on lodgepole pine, in the lava field in the vicinity of CVS plot 2165168, one half mile east off of Forest Road 60, southeast of Indian Heaven Wilderness, Mt. Adams Ranger District, T. 5N, R. 8E, S. 14.
Beatty and Hildebrand searched the stand around CVS plot 1168164, T. 6N, R. 8E, S.20, Wind River Ranger District, and did not find dwarf mistletoe on the mountain hemlock.

Future Survey

The survey will continue in 2000 - 2003, by Jerry Beatty and Diane Hildebrand. Survey for MHDM is expected to be completed by 2004 (after 4 additional survey seasons).

Compliance

This strategy is meeting the requirements for general regional survey for MHDM in Washington. We are gaining additional information on the occurrence of this taxon in Washington. Using the new CVS data and visual reconnaissance from Forest roads is working well. We expect to have a reasonable picture of the incidence of MHDM in Washington, and recommendations for its management, by 2004.

X. MODELING

The simulation model DMLOSS which projects yield losses in black spruce stands infested with *Arceuthobium pusillum* was updated to support using a digitizer to obtain stand information. (F. Baker, Utah State University).

XI. MISCELLANEOUS

WIFDWC Root Disease Committee Meeting

Submitted by Ellen Michaels Goheen

The committee meeting began at 7:30 am, September 17, 1999 with a discussion of how the Root Disease Committee can better facilitate information exchanges on root diseases in the West. It was decided that, at the very least, the committee would sponsor a workshop or panel at WIFDWC meetings. In keeping with the theme of WIFDWC 2000 in Hawaii, the Root Disease Committee will sponsor a panel at that meeting that focuses on exotic root diseases.

The rest of the meeting was spent in round robin discussions and updates:

Other Meetings

Mike McWilliams and Don Goheen reported on the first meeting of IUFRO Working Party 7.02.09, Phytophthora Diseases of Forest Trees, held in Grants Pass, Oregon, August 30 through September 3, 1999. Forty scientists from Europe, Australia, and the United States attended. The gathering was considered a great success. One interesting outcome of the meeting was a set of issues and resolutions that the working party will submit to IUFRO. These included: 1) The need to assess the capacity of "wild" *Phytophthora* species, newly emerging species (including hybrids), and species with currently limited geographical ranges to cause disease in forests in countries where they are not known to occur was recognized. The recommendation was made that germplasm be available between countries for pathogenicity testing and that diagnostic methods be improved and communicated widely. 2) Global warming and associated climate change patterns are likely to favor *Phytophthora*-induced diseases. The group recommended that robust data are needed on the distribution and impacts of *Phytophthora* spp. on forests and other vegetation worldwide. 3) Concerns over movement of diseased planting stock resulted in the recommendation that more comprehensive and effective diagnostic testing of planting stock be done. Working party 7.02.09 will meet again in October 2001 in western Australia.

Gaston Laflamme, the Chairman of IUFRO Working Party 7.02.01, Root and Butt Rots, recently requested contributions to the working party's fall 1999 newsletter which will be published in winter 2000. The Root and Butt Rot Working Party will be meeting in Quebec City, Canada, September 17 – 21, 2001. The website for the meeting is **http://iufro.boku.ac.at/iufro/iufronet/d7/hp70201.html.**

There will be an "ad hoc" meeting of the Coastal *Phellinus* working group in October in Corvallis Oregon. It has been difficult to get this group together in recent years due to travel restrictions. Walt Thies and Rona Sturrock are hoping they can arrange a field trip to look at Walt's *Phellinus*/thinning plots in the Coast Range.

Publications and other technology transfer

Terry Shaw reminded members that there are still copies of USDA Forest service Agriculture Handbook No. 691 Armillaria Root Disease available and that those interested should get in touch with him. He also announced the recent publication of a book on annosus root disease entitled *Heterobasidion annosum* Biology, Ecology, and Control available from CAB International. Bob Edmonds has a new textbook coming out in 2000 that covers fire, wind, insects, and diseases and their interactions. He also has a new video on root diseases of the Pacific Northwest; the intended audience is private landowners. Sue Hagle mentioned that the USDA Forest Service Northern Region Field Guide to Insects and Diseases is available on Region 1's website, **www.fs.fed.us/r1/foresthealth**. John Muir announced that British Columbia Ministry of Forests is updating their field guide. BCMoF also has a recent video on stump pushing technology. Rona Sturrock is nearing completion of a CFS Technology Transfer Note titled 'Management of Root Diseases by Stumping and Push-falling'. The Note includes summarized results on tree mortality from control and treated plots from several stumping trials conducted over the past 30 years in western North America.

Research and Surveys

Rona Sturrock reported on root disease-related activities of the Canadian Forest Service. Research on root disease remains a high priority for the CFS at the Pacific Forestry Centre (PFC) but funding to this and many other research areas is limited. Researchers at PFC work within the objectives of one or two out of a total of ten national CFS Networks. PFC root disease researchers are funded principally by the CFS Effects of Forestry Practices and Forest Biotechnology Networks. A recent review of CFS research resulted in revised Science and Technology priorities, with an emphasis on forestry research related to climate change and biodiversity.

Current root disease research staff at PFC: Duncan Morrison and Mike Cruickshank are working on Armillaria root disease; Rich Hunt continues work on tomentosus root disease, but most of his 99/00 year is being spent on white pine blister rust; Fred Peet is working on root disease modeling; Ralph Nevill moved to a job in Lodi, CA; and Rona is working on laminated root rot.

With funding provided by Forest Renewal British Columbia (FRBC) and the CFS Networks, the principal project Rona is currently pursuing is titled 'Tree improvement – screening coastal Douglas-fir for resistance to *Phellinus weirii* and assessment of resistance mechanisms'. For details on this work see the poster abstract included in this meeting's proceedings.

Sue Hagle described a dieback of western redcedar that they are currently observing in parts of Idaho. Fine root and large root decay appear to both be associated. Sue hopes to be able to investigate this more in the near future.

Fred Baker is working in partially cut spruce stands looking at the impacts and relationships of tomentosus root rot and annosus root disease. He is currently analyzing data and expects to have the results available soon.

Geral McDonald continues his work on basic biology of Armillaria root disease, including investigations on characteristics of Armillaria full sibs developed from laboratory pairing of isolates.

Brennan Ferguson mentioned the work Catherine Parks, Craig Schmitt, and he are doing mapping *Armillaria ostoyae* genets in northeastern Oregon. A paper regarding this work appears in this meeting's proceedings.

Ellen Goheen reported on work she is doing in the southern Oregon Cascades with regard to impacts of annosus root disease in stands that were commercially thinned 20 years ago. She hopes to use this information for Western Root Disease Model validation work as well as build an information base for the disease in her area.

Walt Thies recently initiated a laminated root rot study on Champion International land in western Oregon. Seedlings have been planted adjacent to infested stumps. Overlaid on this are fertilization regimes including varying levels of potassium fertilization. Walt views this study as an opportunity to have hard data on the relationship between potassium fertilization and control of laminated root rot.

John Schwandt brought up the concern that there is much misinformation that continues to be spread about various fertilization regimes and their potential for controlling root diseases. After some fairly lively discussion it was decided that the Root Disease Committee should sponsor a workshop at WIFDWC 2001 on the "Mythology of Fertilization and Root Diseases" with invites to participate going to people directly involved in the various fertilization studies. John also suggested that when possible, pathologist should go to meetings of the fertilizer coops and become involved in their dialogues.

Submitted from Region 2:

Tom Eager, Jeri Lyn Harris, Jim Worrall and Bernard Benton, Forest Health Management, Rocky Mountain Region.are working on the STDP Pest Trend Impact Plots In The West. Cooperators include: Judy Adams, Forest Health Technology Enterprise Team; Jim Friedley, BIA Southern Ute Agency; Don Brake, BLM Gunnison Resource Area Office; Elizabeth Stiller, Randy Rick, Jim Allen and Steve Pische, Black Hills NF; Sam Schroeder, White River NF; Gary Roper, Mike Morrison and Mike Westfahl, Routt NF; Paul Langowski and Steve Johnson, Roosevelt NF; Jon Morrissey, Grand Mesa, Uncompahgre and Gunnison National Forests; Phil Kemp and Bob Vermillion, San Juan NF.

From 1991 to 1998, a network of permanent plots were installed to track the spread and intensification of root diseases, dwarf mistletoes, stem rusts and western spruce budworm in a variety of cover types throughout the Rocky Mountain Region. The objective of the project is to establish a series of permanent plots to provide data for the validation and calibration of various insect and disease computer simulation models. In 1998, all 426 root disease plots were remeasured and the installation of plots to track white pine blister rust in limber and whitebark pine was completed. A total of 22 plots are now installed to study white pine blister rust in Wyoming and South Dakota. Twelve of the plots were established on the Shoshone NF and in Yellowstone NP in whitebark pine stands. Ten plots are in limber pine stands on the Bighorn NF, Medicine Bow NF, Shoshone NF, and in the Black Hills. Additional plots were also installed to monitor subalpine fir decline in Utah and Wyoming. Placement of the data into the PTIPS database and data analysis are currently underway.

Also from Region 2: In 1959, Frank Hawksworth established a study to monitor the effects of Armillaria root disease, *Armillaria ostoyae*, in a young lodgepole pine stand, *Pinus contorta*, west of Ft. Collins, Colorado. The 13-year old stand was approximately 25 acres in size and had naturally regenerated after a clearcut. At the time of study establishment, root rot losses were striking. Disease centers had up to 45 dead trees and averaged 8 per center. Annual mortality was nearly 2 percent in 1960, but had declined to less than 0.5 percent 4 years later. The cumulative mortality over the first 5 years of remeasurement was about 12 percent. This stand was remeasured in 1977, 1985 and 1999. The following data illustrates the effects of the disease over a 40-year period.

> 1977 - 18 yrs. after study establishment; mortality 48 trees/acre (suppressed, non-crop trees); stand fully stocked at 1,292 trees/acre.
>
> 1985 - 26 yrs. later; mortality 10 trees/acre (suppressed, non-crop trees); western gall rust infection 39 trees/acre; stand stocked at 415 trees/acre.
>
> 1999 - 40 yrs. later; no mortality to root disease; 35 percent of lodgepole pines infected with western gall rust main stem cankers or 164 infected trees/acre; stand stocked at 466 trees/acre.

Thanks to all who participated in the discussion and information sharing.

The meeting adjourned at 8:25 am.

WIFDWC Rust Committee Report

Submitted by Brian W. Geils

The Rust Committee lunch was attended by about 20 persons. Brian Geils presided in the absence of Rich Hunt, Chair. As usual the agenda consisted of individual reports on findings, activities, and concerns.

Brian Geils reported on the recent conference at Corvallis, OR for *Ribes*, white pine, and blister rust organized by Kim Hummer (who had attended the previous year's committee meeting). The conference decisions were to assemble a steering committee, to prepare a white paper on the status of blister rust in North America, and to organize collaborative research for screening *Ribes*. Geils also described current work to test a preliminary hazard model published as RMRS RN-6. Blister rust is now known from Gallinas Peak, NM, 50 miles north of previous limit.

Ellen Goheen described a blister rust survey along the high peaks of the Cascade Range and that they have prepared a management guidebook.

John Muir described work in British Columbia. Several new papers were published including studies with Alex Woods on the effect of spacing and by Rich Hunt on sampling accuracy using stem maps and on provenance screening.

Dave Johnson related that in 1959 Frank Hawksworth had examined a 40-year old lodgepole pine stand for Armillaria root rot but also found western gall rust (and stalactiform blister rust) on 35 percent of the trees. That stand is now 30 years older and shows evidence of many cankers at 4--5 feet.

Bill Jacobi gave us details on the recent spread of white pine blister rust to northern Colorado (presumably from the nearby population in southern Wyoming). The infested area is about 12 by 12 miles of scattered limber pine, apparently infected about 1 to 6 years. The infestation about 10 miles north (at Vanadoo) has increased over the past few years. The *Ribes* present include *R. cereum* and another undetermined species.

In early June 1999, Bill Jacobi and Dave Johnson drove roads north and west of Redfeather Lakes, Colorado to determine the extent of limber pines, *Pinus flexilis*, infected by white pine blister rust, *Cronartium ribicola*. In 1998, the rust was first reported on a few pines in the area, but no detailed survey was conducted at that time. This is the first known documented report of the disease in Colorado.

A total of 65 sections were traversed within townships in northern Colorado. The disease was noted in 9 sections. Incidence varied from 3 to 50 percent of sampled trees in affected areas. Cankers appeared to be 3-5 years old. Both main stem and branch cankers were observed. At least two species of Ribes were noted in these areas, one suspected as *R. cereum*.

Jeri Lyn Harris told of their efforts on the Shoshone National Forest and elsewhere in suppression and search for genetically resistant whitebark pine.

Geral McDonald both described some recent work and raised a concern. They have published new papers on the ecology of western white pine and the impact of blister rust (with University of Idaho), for the Boise Fire Symposium, and on overall impact of the rust (with Al Harvey). Geral was concerned over the possible exchange of genetic material between the eastern and western populations of blister rust. This may occur if the rust migrates along the I80-Platte River corridor. Interbreeding could lead to a greater naturalization and adaptation to dryer habitats. There is an urgent need for a continental perspective and good epidemiological models.
John Schwandt spoke of several projects in the Northern Region: a whitebark pine survey, a 30-year pruning-thinning study (can double pine survival), work with the blister rust damage model, and monitoring resistance plantations (need a new plantation with all the resistance components represented).

Sally Campbell reported on projects at the Dorena Screening Center with the Champion Mine race.

Jim Hoffman began a discussion of the significance of possible genetic exchange between the eastern and western blister rust populations by suggesting there may be greater rust spread in the future due to ornamental, landscape planting of hosts. The issues considered were how different are the two populations, importance of evolutionary adaptation, and significance of planted *Ribes* given the abundance and distribution of natural populations.

WIFDWC - 1999
Rocky Mountain Region Report

1. New and Continuing Projects

D. Root and Soil Diseases or Relationships (including Mycorrhizae)

95-D-2 Ski area vegetation management: biology and impacts of the Armillaria root disease/western balsam bark beetle complex (T. Eager, J. Negron).

90-D-2 Root disease impact monitoring (D. Johnson)

F. Stem Diseases: Malformations, Witches'-Brooms, Dwarf Mistletoes, Etc.

85-F-5 Silvicultural control of dwarf mistletoe in young lodgepole pine stands (B. Geils, D. Johnson).

K. Miscellaneous Studies

98-K-1 GIS-based landscape-scale prediction system for pinyon pine decline (W. Jacobi, S. Harrison, T. Eager, R. Mask).

COOPERATORS: Eric Smith, Forest Health Technology Enterprise Team; Jose Negron and John Lundquist, Rocky Mountain Forest and Range Experiment Station; Robin Reich and Gene Kelly, CSU; John Guyon, R4 FHP; Terry Rogers, R3 FHP; Phil Kemp, Eric Lindroth and Dan Greene, Dolores Ranger District, San Juan NF; Jim Friedley, BIA Southern Ute Agency; John Waconda, BIA Albuquerque Area Office; Dan Ochocki, Colorado State Forest Service, Durango District.

YEARS: Begun- 1998; End- 2000

PROJECT OBJECTIVE: To produce a GIS-based landscape scale prediction system for incidence of pinyon pine decline in Southwest Colorado. The general principles of this model will be applicable, with local modifications, to pinyon/juniper forests throughout the Intermountain West.

PROJECT DESCRIPTION: Although a variety of causes are responsible for decline of pinyon pine in various areas, in many locales the key agents are black stain root disease (Leptographium wageneri) and pinyon ips (Ips confusus). Using aerial photography and site visits by field personnel, mortality centers in pinyon pine on the San Juan National Forest and Southern Ute Indian Reservation will be located and entered into a GIS database along with soil and site characteristics and locations of disturbed areas. By analyzing the data using spatial statistics, a hazard rating system will be developed for pinyon pine decline in Southwest Colorado.

During the 1998 field season, conventional and digital color infrared aerial photographs were acquired in the study areas on the San Juan NF and Southern Ute Indian Reservation. Ground transects were run over a sample of mortality sites, where insect, disease and site characteristics were recorded.

97-K-1 Stand characterization and manipulation associated with western balsam bark beetle and decline of subalpine fir in the central Rocky Mountains (T. Eager).

90-K-1 Vegetation management planning in developed recreation sites (D. Johnson, J. Worrall).

2. Terminated Projects

79-D-1 Surveys of root diseases in managed conifer stands in R-2

97-K-1 Effectiveness of fire for site preparation in seral aspen in western Colorado.

Recent Publications (as of September 1999)

Allen, K.K. and J.L. Harris. 1997. Evaluation of forest overstory and regeneration conditions at the Bessey and McKelvie units of the Nebraska National Forest. USDA For. Serv., Renewable Resources, Rocky Mountain Region Biol. Eval. R2-98-1. 12 p.

Allen, K.K. 1998. Evaluation of mountain pine beetle activity in the Kine Analysis Area of the Black Hills National Forest. USDA For. Serv., Renewable Resources, Rocky Mountain Region Biol. Eval. R2-98-05. 11 p.

Allen, K.K. and J.D. McMillin. 1998. Evaluation of mountain pine beetle activity in the Steamboat Rock and Beaver Park areas on the Spearfish/Nemo Ranger District of the Black Hills National Forest. USDA For. Serv., Renewable Resources, Rocky Mountain Region Biol. Eval. R2-99-01.

Harris, J.L., K.K. Allen, and T. Juntti. 1997. Ramshorn Analysis Area, Wind River Ranger District, Shoshone National Forest, insect and disease survey. USDA For. Serv., Renewable Resources, Rocky Mountain Region Biol. Eval. R2-98-04. 31 p.

Harris, J.L., K.K. Allen, and J. McMillin. 1998. Little Bighorn Analysis Area, Medicine Wheel and Tongue Ranger Districts, Bighorn National Forest. Insect and Disease Survey. USDA For. Serv., Renewable Resources, Rocky Mountain Region Biol. Eval. R2-99-03. 25 p.

Harris, J.L 1999. Evaluation of white pine blister rust disease on the Shoshone National Forest. USDA For. Serv., Renewable Resources, Rocky Mountain Region Tech. Rep. R2-99-05. 11 p.

Harris, J.L. 1999. Phomopsis Blight at Bessey Nursery. USDA For. Serv., Renewable Resources, Rocky Mountain Region Biol. Eval. R2-99-07. 6 pp.

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Johnson, D.W. 1998. Evaluation of Hidden Lakes dwarf mistletoe pruning study, Routt National Forest, Colorado. USDA For. Serv., Renewable Resources, Rocky Mountain Region Tech. Rep. R2-61. 8 p.

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WIFDWC Past Meeting Locations and Executive Committees

YR	LOCATION	CHAIRMAN	SECY/TR	PROGRAM CHAIR	LOCAL ARRNGEMNTS
53	Victoria, BC	R. Foster			
54	Berkeley, CA	W. Wagener	P. Lightle		
55	Spokane, WA	V. Nordin	C. Leaphart	G. Thomas	
56	El Paso, TX	L. Gill	R. Davidson	V. Nordin	
57	Salem, OR	G. Thomas	T. Childs	R. Gilberston	
58	Vancouver, BC	J. Kimmey	H. Offord	A. Parker	
59	Pullman, WA	H. Offord	R. Foster	C. Shaw	
60	Centralia, WA	A. Parker	F. Hawksworth	J. Parmeter	K. Shea
61	Banff, AB	F. Hawksworth	J. Parmeter	A. Molnar	G. Thomas
62	Victoria, BC	J. Parmeter	C. Shaw	K. Shea	R. McMinn
63	Jackson, WY	C. Shaw	J. Bier	R. Scharpf	L. Farmer
64	Berkeley, CA	K. Shea	R. Scharpf	C. Leaphart	H. Offard
65	Kelowna, BC	J. Bier	H. Whitney	R. Bega	A. Molnar
66	Bend, OR	C. Leaphart	D. Graham	G. Pentland	D. Graham
67	Santa Fe, NM	A. Molnar	E. Wicker	L. Weit	P. Lightle
68	Couer D'Alene ID	S. Andrews	R. McMinn	J. Stewart	C. Leaphart
69	Olympia, WA	G. Wallis	R. Gilbertson	F. Hawksworth	K. Russell
70	Harrison Hot Springs, BC	R. Scharpf	H. Toko	A. Harvey	J. Roff
71	Medford, OR	J. Baranyay	D. Graham	R. Smith	H. Bynum
72	Victoria, BC	P. Lightle	A. McCain	L. Weir	D. Morrison
73	Estes Park, CO	E. Wicker	R. Loomis	R. Gilbertson	J. Laut
74	Monterey, CA	R. Bega	D. Hocking	J. Parmeter	
75	Missoula, MT	H. Whitney	J. Byler	E. Wicker	O. Dooling
76	Coos Bay, OR	L. Roth	K. Russell	L. Weir	J. Hadfield
77	Victoria, BC	D. Graham	J. Laut	E, Nelson	W. Bloomberg
78	Tuscon, AZ	R. Smith	D. Drummond	L. Weir	R. Gilbertson
79	Salem, OR	T. Laurent	T. Hinds	B. van der Kamp	L. Weir
80	Pingree Park, CO	R. Gilbertson	O. Dooling	J. Laut	M. Schomaker
81	Vernon, BC	L. Weir	C.G. Shaw III	J. Schwandt	D. Morrison/R. Hunt
82	Fallen Leaf Lake, CA	W. Bloomberg	W. Jacobi	E. Hansen	F. Cobb/J. Parmeter
83	Coeur D'Alene, ID	J. Laut	S. Dubreuil	D. Johnson	J. Schwandt/J. Byler
84	Taos, NM	T. Hinds	R. Hunt	J. Byler	J. Beatty/E. Wood
85	Olympia, WA	F. Cobb	W. Thies	R. Edmonds	K. Russell
86	Juneau, AK	K. Russell	S. Cooley	J. Laut	C. G. Shaw III
87	Nanaimo, BC	J. Muir	G. DeNitto	J. Beatty	J. Kumi
88	Park City, UT	J. Byler	B. van der Kamp	J. Pronos	F. Baker
89	Bend, OR	D. Goheen	R. James	E. Hansen	A. Kanaskie
90	Redding, CA	R. Hunt	J. Hoffman	M. Marosy	G. DeNitto
91	Vernon, BC	A. McCain	J. Muir	R. Hunt	H. Merler
92	Durango, CO	D. Morrison	S. Frankel	C. G. Shaw III	P. Angwin
93	Boise, ID	W. Littke	J. Allison	F. Baker	J. Hoffman
94	Albuquerque, NM	C. G. Shaw III	G. Filip	M. Schultz	T. Rogers
95	Whitefish, MT	S. Frankel	R. Mathiasen	R. Mathiasen	J. Taylor/J. Scwandt
96	Hood River, OR	J. Kliejunas	J. Beatty	S. Campbell	J. Beatty/K.Russell
97	Prince George, BC	W. Thies	R. Sturrock	K. Lewis	R. Reich/K. Lewis
98	Reno, NV	B. Edmonds	L. Trummer	G. Filip	J. Hoffman/J. Guyon
99	Breckenridge CO	F. Baker	E. Michaels Goheen	J. Taylor	D. Johnson

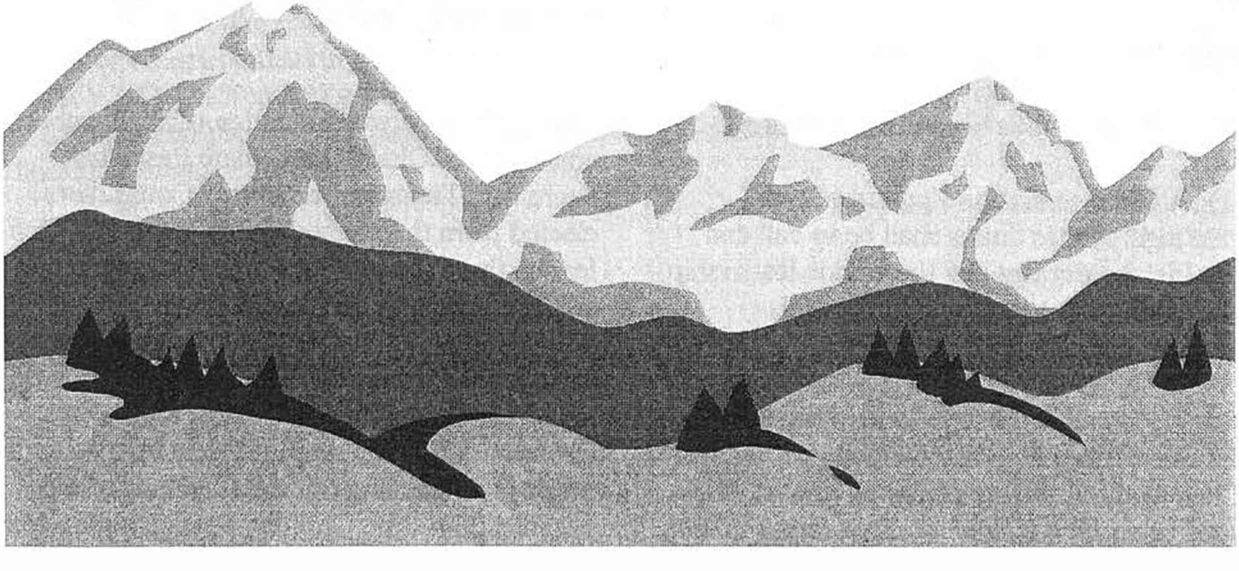
WIFDWC Honorary Members

Living and Deceased (D)

"Honorary Members are WIFDWC members who have retired from continuous employment in the field of forest pathology"

Paul Aho 84	Norm Alexander 94	Ed Andrews 77
Stuart "Stuie"Andrews (D) 73	Jesse Bedwell (D) 66	Robert Bega (D) 85
Warren Benedict (D) 66	John Bier (D) 67	Dick Bingham 75
Bill Bloomberg (D) 90	Roy Bloomstrom (D) 92	Thomas Buchanan (D) 72
Don Buckland (D) 56	Hubert "Hart" Bynum (D) 72	Elmer Canfield 83
Toby Childs D 68	Fields Cobb 93	Ross Davidson (D) 68
Oscar Dooling (D) 86	Charles Driver 92	Norm Engelhart (D) 59
David Etheridge 75	Lowell Farmer 65	Mike Finnis 84
Ray Foster 75	Dave French (D) 95	Alvin Funk 89
Lake Gill D 66	Linnea Gillman 80	James Ginns 96
Clarence Gordon (D) 81	Don Graham 80	John Gynn (D) 66
John Hansbrough (D) 68	Hans Hansen (D) 60	John Hart 99
Homer Hartman (D) 66	Bob Harvey 92	George Harvey (D) 76
Frank Hawksworth (D) 91	Dwight Hester (D) 83	Tommy Hinds 85
Ray Hoff 95	John Hopkins 87	Benton Howard (D) 71
John Hunt D 59	Paul Keener (D) 67	James Kimmey (D) 66
Tom Laurent 85	John Laut 93	Don Leaphart (D) 75
Paul Lightle 73	Otis Maloy 91	Neil Martin 89
Art McCain 93	Tom McGrath 97	Neil McGregor (D) 77
Jim Mielke (D) 66	D. Reed Miller (D) 70	Alex Molnar 76
Virgil Moss (D) 66	Earl Nelson 95	Tom Nicholls 95
Vidar Vordin 92	Harold Offord (D) 65	Nagy Oshima (D) 76
Lee Paine 81	Dick Parmeter 91	Roger Peterson 94
Clarence Quick (D) 68	Jerry Riffle 86	Jack Roff 75
Lew Roth 79	Ken Russell 96	Bob Scharpf 91
E. Mike Sharon 95	Charles G. Shaw (D) 84	Pritam Singh 97
Albert Slipp (D) 60	Richard B. Smith 90	Richard S. Smith 95
Willhelm Solheim (D) 65	James L. Stewart	Jack Sutherland 96
Al Tegethoff 80	Phil Thomas (D) 76	Jim Trappe 86
Eugene Van Arsdell	Allan Van Sickle 97	Willis Wagener (D) 65
Gordon Wallis 83	Charles "Doc" Waters (D) 60	Larry Weir 84
Conrad Wessela 66	Stuart Whitney 91	Roy Whitney 90
Ed Wicker 91	Ralph Williams 94	John Woo (D) 86
Ernest Wright (D) 65	Bratislav Zak 76	Wolf Ziller (D) 73

WFIWC
Constitution
Minutes of the 1998 Business Meetings
Minutes of the 1999 Business Meetings



CONSTITUTION
OF THE
WESTERN FOREST INSECT WORK CONFERENCE

Article I Name

The name of this organization shall be the Western Forest Insect Work Conference.

Article II Objects

The conference is organized exclusively for charitable, educational, religious, or scientific purposes within the meaning of section 501(c)(3) of the Internal Revenue Code.

The objects of this organization are (1) to advance the science and practice of forest entomology, (2) to provide a medium of exchange of professional thought, and (3) to serve as a clearing house for technical information on forest insect problems of the western United States and Canada.

Article III Membership

Membership in this organization shall consist of forest entomologists and others interested in the field of professional forest entomology. Official members shall be those who pay registration fees.

Article IV Officers and Duties

The Officers of this organization shall be:

(1) A Chair to act for a period of two meetings, whose duties shall be to call and preside at meetings and to provide leadership in carrying out other functions of this organization.

(2) An Immediate Past Chair, who shall assume office immediately upon retiring as Chair without further election; whose duties shall be to fill the chair at any meeting in the absence of the Chair; to act until the election of a new Chair.

(3) A Secretary to act for a period of two meetings whose duties shall be to keep a record of Executive Actions, record minutes of Executive Committee and conference business meetings, to maintain committee correspondence, and to send out notices, reports, and proceedings. The Secretary is charged with the responsibilities of coordinating preparation of the proceedings (amended Feb. 28, 1967, Las Vegas, NV and Sept. 15, 1989, Bend, OR).

(4) A Treasurer, who is a non-voting member of the Executive Committee, to act for an indefinite term, whose duties shall be to keep a record of funds collected and disbursed, to issue monies for approved purposes, to maintain a record of members, committees, and officers, and to provide mailing lists and/or labels as needed. The Treasurer will provide financial records for inspections by a two-member Executive audit team, comprised of the Chair and Immediate Past Chair annually prior to the Executive Committee meetings (amended Sept. 15, 1989, Bend, OR).

(5) An Executive Committee of six members consisting of Chair. Immediate Past Chair, Secretary, Treasurer, and three Counsellors elected from the membership. Terms of office for the three Counsellors shall be staggered and for a period of three meetings each. The duties of the Committee shall be to carry out actions authorized by the Conference; to authorize expenditures of funds, and to establish policies and procedures for the purpose of carrying out the functions of the organization. The Conference registration fee

will be set by the Local Arrangements Committee in consultation with the Secretary, Treasurer, and Chair (amended March 4, 1965, Denver, CO and Sept. 15, 1989, Bend, OR).

The officers shall be elected at the Annual Meeting. Their periods of office shall begin at the conclusion of the meeting of their election.

The Chair shall have the power to appoint members to fill vacancies on the Executive Committee occurring between meetings. The appointment to stand until the conclusion of the next general meeting.

It is the responsibility of a Counsellor, should he or she be unable to attend an executive meeting, to appoint an alternate to attend the executive meeting and to advise the Chair in writing accordingly. The alternate shall have full voting privileges at the meeting to which he or she is designated.

Article V Meetings

The objectives of this organization may be reached by holding at least an annual conference and such other meetings as the Chair, with the consent of the Executive Committee, may call. The place and date of the annual meeting shall be determined by the Executive Committee after considering any action or recommendation of the conference as a whole. The secretary shall advise members of the date and place of meetings at least three months in advance.

Article VI Proceedings

A record of proceedings of the conference shall be maintained and copies provided to members in such form as may be decided as appropriate and feasible by the Executive Committee.

Article VII Amendments

Amendments to the Constitution may be made by a two-thirds vote of the total conference membership attending any annual meeting.

Article VIII Article of Dissolution

Upon the dissolution of the Conference, the Executive Committee, shall after paying or making provisions for the payment of all the liabilities of the Conference, dispose of all the assets of the Board exclusively for the purposes of the Conference in such manner, or to such organization or organizations organized and operated exclusively for charitable, educational, religious, or scientific purposes as shall at the time qualify as an exempt organization or organizations under section 501 (c)(3) of the Internal Revenue Code of 1986 (or as the Executive shall determine. Any such assets not so disposed of shall be disposed of by the Court of Common Pleas of the county in which the principle office of the Board is then located, exclusively for such purpose or to such organization or organizations, as said Court shall determine, which are organized and operated exclusively for such purposes.

Prepared by Richard Washburn
March 20, 1969
Revised 4 March 1993
Revised 15 April 1997

WESTERN FOREST INSECT WORK CONFERENCE
49th ANNUAL MEETING
JACKSON, WYOMING

Executive Committee Meeting
2 March 1998

Present were: Lorraine Maclauchlan, Chair
Don Dahlsten, Past Chair
Ladd Livingston, Treasurer
Ann Lynch, Secretary, CG&PC
Mike Wagner, Counselor
Ed Holsten, Counselor

Steve Burke, Memorial Awards Committee
Boyd Wickman, Founders Award Committee, History Committee
Mal Furniss, History Committee
Dave Johnson, WIDWC representative for 1998 Conference Committee
Bill Schaupp, 1998 Local Arrangements

Counselor Bob Hodgkinson was not present.

Minutes of the Final Business Meeting held on 17 April 1997 were distributed in the Conference Proceedings. Mike Wagner moved to accept the minutes, Don Dahlsten seconded, and motion passed.

Committee Reports and Related Business

Ladd Livingston read the Treasurer's Report. Don Dahlsten and Lorraine Maclauchlan will audit the books after the Executive Committee meeting. A temporary committee, comprised of Peter Hall, Jill Wilson, and Ladd Livingston, appointed last year to make a recommendation regarding distribution of funds, recommended that the Conference retain a balance of $3,000 in the checking account for Conference business. Ladd summarized the background on the source of funds: The original large surplus was generated at the Park City meeting when the Forest Service covered proceedings costs. The next significant addition was from Penticton, when many more people attended than were expected. Last year's expenses are not final yet, but an additional $5,000 might be added.

Steve Burke asked when the Conference last lost money at a conference? That was 1974 at Mount Hood, at the direction of the Executive Committee. Discussion ensued, with retained fund recommendations being made between $3,000 and $5,000. Deposits needed by conference hotels have ranged between $200 and $2,000. It was agreed that the Chair will bring the issue up for vote at the Initial Business Meeting.

Ann Lynch asked about tax-exempt status. Ladd indicated that they are still working on it, and that progress is being made. Bob Hodgkinson kept excellent records on the scholarship funds.

Ann moved we accept the Treasures Report, Ed Holsten seconded, motion passed.

There was no report from the Common Names Committee.

Mal Furniss read a report from the History Committee. It will be read at the Initial Business Meeting. A paper copy was given to the Secretary, and an electronic copy will be mailed to Jesse Logan. Ladd Livingston moved we accept the report, Don Dahlsten seconded, motion passed.

Boyd Wickman read a report from the Founders Award Committee, and gave a written copy to the Secretary for word processing. Ken Gibson has replaced John Borden on the Committee. Two nominations were received and there will be an Award given. Dave Johnson was hereby informed of the addition to the 1999 Program for the Award acceptance address.

Boyd brought to the table the issue of providing a travel stipend to be provided with the award so that awardee's, who are often retirees, can attend the Work Conference. After discussion, Ann Lynch moved that the Work Conference provide room, registration, and banquet ticket with the award; Ladd seconded, approved.

Steve Burke read a report from the Memorial Awards Committee; he will send an electronic copy to Jesse Logan. Ladd displayed an *Ips pini* belt buckle that he designed for the Work Conference as a fund raiser for the Memorial Awards, which he hopes is available for distribution at this meeting. Production cost is approximately $10 each; after discussion, it was agreed to offer the buckles for $20.

Boyd Wickman mentioned concern about lack of member participation in getting names on the plaque. Ladd Livingston says that visibility is a problem. Ann indicated that a conference web site might help, and that she would like to include photos and the belt buckle image on the web site, especially a photo of Mark McGregor.

Don moved to accept the Committee Report with an addition regarding the belt buckles; Mike Wagner seconded, motion passed.

Ann Lynch read a report from the Conference Guidelines & Proceedings Committee, acknowledging contributions from the Jackson Conference Committee and Frances Barney, retired Librarian at the Rocky Mountain Research Station. Ann asked Dave Johnson and Bill Schaupp to keep good records on conference organization. Steve Burke moved that the report be accepted, Mike Wagner seconded, motion passed.

Mike Wagner, Don Dahlsten, and Ed Holsten were appointed to a Nominating Committee for the Chair and Counselor positions. It was clarified that the Treasurer's position is filled until the Treasurer steps down or is recalled.

Old Business

Ann Lynch reported for the Jackson Conference Committee. The Conference is paying for one meeting room per day; the rest are covered by the number of lodging rooms taken. There will be no-host bars at both the mixer and before the banquet. The Ogden publication staff has agreed to produce the proceedings, news that was enthusiastically received by the Committee. Discussion ensued to the effect that it needs to be clear that the proceedings cannot be published in a Station series.

Materials from the Society of American Foresters Entomology and Pathology Working Group are available for review on the registration desk. These pertain to SAF's revision of their forestry and natural resources publication. Comments should be sent to Ann Lynch.

Dave Johnson reported for the WIDWC on the 1999 joint meeting in Breckinridge. His report will be given at the initial business meeting.

Lorraine will contact Jan Volney and Darrell Ross, or others, for status reports on the 2000 and 2001 meetings.

New Business

Ann Lynch brought up an issue regarding the Treasure's position being non-voting. She said that the Treasurer knows more about Work Conference operations and executive issues than anyone, and would like to make a motion at the Initial Business Meeting to change this to a voting position. There were no objections. Discussion indicated that the original reason for this being a non-voting position is because it is a standing position, which could give the Treasurer undue influence in Conference business.

Ladd Livingston indicated that all members are supposed to be listed in the Proceedings, and that copies are supposed to be mailed to all active members. Only attendees were listed in last year's Proceedings. It was agreed that the Treasure or Secretary should remind proceedings' compilers of this after each meeting, and that these instructions need to be included in the Conference Guidelines document.

Ladd Livingston reviewed the process for distributing any excess funds from a joint meeting; basically, that they are distributed based on attendance numbers.

Ann Lynch moved for adjournment at 7:20, Ladd Livingston seconded, motion passed.

CG&P Committee Report

Submitted by Ann Lynch, Committee Chair

Committee work during the last year included progress in three areas: Proceedings library distribution, conference guidelines, and establishing a WWW site.

Terry Shore has been compiling a mailing list of the appropriate Canadian libraries for receiving the Proceedings. The retired librarian at the RMRS, Frances Barney, is compiling similar information for US agency depositories. US university and Mexican libraries have not been addressed yet.

Ann Lynch has been working on preparing a conference guidelines document. Barbara Bentz and Jesse Logan assisted in this years effort. A draft document is expected to be distributed for review this fall.

WWW. Work on establishing web site was delayed while Chair worked on Proceedings guidelines. Currently, we are waiting for approval to put the web site on at RMRS.

WESTERN FOREST INSECT WORK CONFERENCE
49th ANNUAL MEETING
JACKSON, WYOMING

Initial Business Meeting
3 March 1998

Chair Lorraine Maclauchlan called the meeting to order at 8:10 am.

The Chair asked for information regarding status of members. The following people have retired: Jed Dewey from Region One, Leroy Kline from the State of Oregon, and Richard Mason from the Pacific Northwest Station.

The minutes from the 1997 Final Business Meeting were distributed in the Proceedings. Ladd moved that the minutes be approved; motion was seconded and passed. The 1997 Proceedings are still being mailed to members who did not attend that meeting.

Secretary Ann Lynch read the minutes from Monday's Executive Committee meeting. Boyd Wickman moved that the minutes be accepted, Ken Gibson seconded, minor corrections were noted, and motion passed.

Ladd Livingston read the Treasurer's Report. This raised the issue of what balance should be left in the Conference checking account, with any additional funds going into the memorial scholarship fund. This action should bring the scholarship fund to a level where a scholarship might be awarded next year. At the Chair's request, Don Dahlsten moved that the Treasure's Report be accepted, seconded by Boyd Wickman, motion passed. Ann Lynch moved that we retain $4,000 in the Conference checking account, and that additional funds be moved to the Memorial Scholarship fund; motion seconded by Elizabeth Tomlin, motion passed. The Chair reported that she and Don Dahlsten found the books to be in order.

Committee Reports

Submitted committee reports are included in the Proceedings.

There was no report from the Common Names Committee.

Mal Furniss read the report submitted by himself and Boyd Wickman from the History Committee. Mal invited members to attend the "Glimpses of the Past" workshop sponsored by the History Committee on Wednesday afternoon.

Boyd Wickman reviewed the history of the Founders Award Committee before reading the committee report. The Committee has been in existence only 10 years, and was formed to recognize members that have made significant contributions to the profession. This is not an easy award to receive, and has been awarded only six times in the last ten years. Currently, the committee includes Ken Gibson, Staffan Lindgren, Les Safranyik, Boyd Wickman, and Jill Wilson. Boyd invited further nominations, and instructions can be obtained from him.

Steve Burke reviewed the history of the Memorial Scholarship Awards Committee before reading the committee report. An initiative to create a scholarship award in the memory of Mark McGregor was undertaken after he died in the field north of Coeur d'Alene in 1990. Since then, other members have asked for recognition of other deceased members, and these efforts have subsequently been combined. John Schmid undertook the production of a memorial plaque that commemorates deceased members in who's names $50 or more has been donated, recipients, and significant sponsors. The committee currently includes Steve Burke, Ladd Livingston, Karen Ripley, and Boyd Wickman. Steve asked for volunteers at the History Committee table. There will be a committee meeting at breakfast tomorrow, and interested people are invited to attend. Topics tendered for discussion include:

Not-for-profit status,

New fund raising initiatives,

Estate funds potentially available for this scholarship fund,

Minimum donations needed for engraving significant sponsors on the plaque,

The financial limit set in the Terms of Reference for initiating awarding a scholarship,

Do we want to list the names of those deceased members that have had their names engraved on the plaque, and

Development of protocols for nomination and award of scholarships. During discussion, Steve Burke indicated that he did not think it appropriate for the fund-raising committee to serve as the nominating committee. At the final business meeting, the Conference Chair will accept volunteers or appoint people to a scholarship awards committee at the final business meeting.

Ann Lynch reviewed the history of the Conference Guidelines and Proceedings Committee before reading the committee report. The organizers of the Rapid City meeting complained about lack of guidance when they began planning the meeting. The Conference chair appointed a committee with two objectives: to develop a meeting planning document for the WFIWC, and to develop a list of libraries to receive copies of the Proceedings. Since then, the objective of developing a Web site has been added.

Old business

Dave Johnson reported on arrangements for the joint meeting of the WIDWC and the WFIWC. The meeting will be held 13-17 September 1999 at The Village at Breckinridge; a contract has been signed with the hotel. Hopefully, the timing will coincide with autumn color, days should be warm, and nights cool. There are many opportunities for field trips, including an expanding mountain pine beetle outbreak at Vail, and mountain pine beetle and fir decline in the Dillon valley. A poster session will be included.

Darrel Ross reported that he thought he was organizing the meeting for 2001, not 2000, and will adjust his plans accordingly. He anticipates no difficulties. Ann asked to be kept up to date so that she can post information on the Web.

No one is here from Edmonton to report on the 2001 meeting. Ron Billings indicated that Jan Volney is forming a steering committee, and is looking for representatives from each Work Conference. Lorraine Maclauchlan will try to reach Jan before the final business meeting.

The Conference Chair reminded moderators to organize proceeding contributions and send them to Barbara Bentz. Ken Gibson asked for copies of older Proceedings, and any paraphernalia that can be offered for sale by the Memorial Scholarship Committee.

New Business

1. Ann Lynch made a motion to amend Article IV(4) of the Constitution to read "A Treasurer, who is a voting member of the Executive Committee". She indicated that, due to turn over in the other positions, the Treasurer knew more than others about how the Work Conference operated and the history of various issues, and that she thought the Treasurer should have Executive powers; however, some members might not be comfortable with giving such power and influence to a position with long tenure. The Motion was seconded by Boyd Wickman. Steve Burke noted that this would result in a tie-breaking committee number. A vote was called for and motion passed with more than two thirds of the attending members in favor.

2. John Moser made a motion (attached) regarding funding for a Scolytus publication effort. Steve Siebold/Sebel seconded. John Borden wants to amend the motion to include the Canadian government, NSF, etc. John Dale asked that the motion be posted during the conference, and considered at the final business meeting. The motion was tabled until the final business meeting, and Ladd Livingston asked for interested members to meet with John regarding any amendments.

3. Ladd Livingston reported that he attended Jed Dewey's and Leroy Kline's retirement receptions, and that he thought the prepared comments made at those receptions were of historical interest to the Conference, and would make good additions to the historical record. The Secretary indicated that such documents can be submitted to be included in the minutes, and therefore in the Proceedings. Ladd wants us to actively seek out such records. The consensus reached was that this effort be included in the History Committee responsibilities.

4. Barbara Bentz reported that there are 98 registered participants. Ladd Livingston moved for adjournment at 9:15, seconded by Ann Lynch, motion passed.

WESTERN FOREST INSECT WORK CONFERENCE
49th ANNUAL MEETING
JACKSON, WYOMING

Final Business Meeting
5 March 1998

*** UNAPPROVED MINUTES ***

Chair Lorraine Maclauchlan called the meeting to order at 8:30 am.

Secretary Ann Lynch read the minutes from the Initial Business Meeting. Ken Gibson moved to accept the minutes, Terry Rogers seconded, minor corrections were noted, and the motion was passed.

Members noted that several members, not noted earlier, had retired: Max Olieu, Lynne Rasmussen Int Stm, George Ferrell, and Ardin Tagsdad. Also, past member Jukka Celan of Finland, who was a Kellogg Fellow under Ron Stark at the University of Idaho, died in February of 1997 of complications from a tick-bourne disease.

Committee Action

1. Founders Award. Boyd Wickman re-announced Mal Furniss as recipient of the Founders Award. He also noted that Gene Amman and Mal Furniss are both in attendance, and it is very rare that we have two winners attending the same meeting. The Executive Committee approved production of a plaque listing Award recipients. The plaque and photos of recipients are to be exhibited at the next meeting.

Jill Wilson volunteered to provide Award nomination and recipient information for posting on the Web site.

John Borden asked for clarification regarding nominations being valid for three years. Boyd said that nominations could be re-submitted two additional years. A motion was made from the floor that all nominations stay active for three years without a re-submission, seconded by Ladd Livingston, and passed.

2. Memorial Scholarships. Chair Lorraine Maclauchlan reported that she, Steve Burke, Boyd Wickman, Ladd Livingston, and Karen Ripley met to discuss Scholarship awards. Formation of a committee comprised of one Canadian, two U.S., one Mexican, and one changeable members was recommended. The Chair appointed herself, Boyd Wickman, Don Dahlsten, Mike Wagner, and David Cibrion-Tobar to a Memorial Scholarship Selection Committee, subject to David's agreement. Ladd Livingston indicated that $750 U.S. should be available for a scholarship next year. The Committee will develop any necessary terms of reference, protocols, plaques, nomination and award procedures, etc., and include that information in the next mailing or on the Web site.

It was also decided that a contribution of $1,500 U.S. is required for designation as a significant sponsor. Some sponsors who have already given $500 or more will be grand fathered in, including the McGregor and Trostle families.

A fund-raising auction is being considered for the next meeting, and members are asked to contribute interesting historical memorabilia. Ladd Livingston expressed appreciation for contributions, and indicated that only 13 of 50 belt buckles are left. Ann Lynch indicated that if we acquire tax-exempt status for the Scholarship, then members in the United States could claim contributions beyond costs against taxes.

Boyd indicated that he was having difficulty getting women to buy the belt buckle. After energetic discussion and several suggestions, the Chair called for order, and Boyd was advised to use his judgement regarding appropriate action.

Old Business

1. Moser motion: John Moser proposed amending his Scolytidae motion to read "Therefore let it be resolved.... USFS Aphis, and the equivalent agencies in Canada and Mexico". Lee Humble moved to approve the amendment, Ladd Livingston seconded, amendment passed. After lengthy discussion regarding wording, consensus was reached that the attending membership was in agreement with the intent of the motion, that the writers could wordsmith as needed, and that once approved it should be returned to Steve Wood with a letter instructing him to use it in his correspondence and search for funds, and encouraging him to communicate with the Conference if we can assist him. The Chair called for a vote, and the motion passed unanimously.

2. Nominations Committee: Mike Wagner reported that the Committee nominates Tom Eager for Chair and Darrell Ross as Counselor, and made a motion that the nominations be accepted. The motion was seconded and passed.

3. Jackson Conference. Workshop moderators were instructed to send summaries to the Program Committee member who requested their participation by June.

Boyd Wickman expressed appreciation for the fine program, indicating that it was one of the best.

Barbara Bentz indicated that attendance was approximately 105 people.

New Business

1. International attendance: John Borden indicated that it is too expensive for most Mexican students and professionals to ever come to a meeting. He asked that the Executive Committee place this issue on their agenda for discussion. Member discussion on this issue included the following items:

> Is there some way that small travel grants can be given to subsidize travel for those from Mexico?
>
> Relatively few Canadians came, due to expensive travel costs. Many more Canadians come when the meetings are held in Canada.
>
> The possibility of hosting a meeting in Mexico. Discussion indicated that the Mexican invitation to host the NAFIWC was declined in favor of the Edmonton invitation in part because of doubt about ability to adequately host the meeting. Many members expressed a high level of confidence that a Mexican meeting would be extremely well hosted. Jill Wilson asked if holding the Conference close to Mexico would help? Mike Wagner indicated that it took 12 to 14 hours for Mexicans to cross the border for the recent joint Southwestern SAF/Mexican Society of Professional Foresters meeting in Flagstaff. Ron Billings indicated that he would contact several people in Monterey and Mexico City on this issue.

2. 1999 meeting: Evan Nebeker indicated that the meeting dates conflict with the SAF Annual Convention. He also encouraged WFIWC members to submit articles to the *Journal of Forestry*. Ann Lynch reminded members that the 1999 meeting will be the Conference's 50th meeting, and asked if any special attention would be paid to this occasion. Boyd Wickman indicated that the History Committee will do a session commemorating the occasion. Ann asked for a poster presentation as well.

3. Conference format: Don Dahlsten encouraged a return to the old conference format of informal discussion, rather than the recent tendency towards formal slide presentations. A less formal format encourages discussion participation by more people, and brings younger people into the discussion. The Conference Chair praised this conference as being particularly good about going back to the old format.

4. Student papers: Karen Ripley wants student presentations to be made to the entire body. Jesse Logan, Program Chair for this meeting, said that that was not practical, that there is plenty of representation in the student sessions, and that they are less stressful for the students when held as student sessions. Holding two sessions grouped by topics was suggested. Darrell Ross, who moderated this session the last two years said that he worries about contacting students, and likes to have a "request for student papers" included in the pre-meeting mailings, and that he suggests to his students that they present work-in-progress rather than formal results-oriented papers. Don Dahlsten asked for comments from the students on session format. Replies indicated more comfort with the smaller session; some benefits to holding formal sessions and presentations to the entire membership; suggestions of holding two sessions, one formal and one

informal; comments to the effect that the 1989 (Bend OR) student session worked very well - it was an informal special evening session coinciding with the mixer, with people dropping in and out; and conflicts between attending the student session or a workshop.

5. Joint meeting, 1999: Dave Johnson asked for guidance on organizing the joint meeting, as concurrent but separate WFIWC and WIDWC meetings or as a combined meeting. Discussion indicated that a) the Program Committee is free to organize the meeting as they think best, b) an integrated format with plenary and then concurrent workshops probably works best. The Bend Committee tried a mix of both approaches, and the Albuquerque Committee tried to integrate as much as possible. Separate business meetings are necessary.

6. Ann moved to adjourn at 9:30, seconded by Terry Rogers, and motion passed.

WESTERN FOREST INSECT WORK CONFERENCE
50th ANNUAL MEETING
BRECKENRIDGE, COLORADO

Executive Committee Meeting
13 September 1999

Present were: Tom Eager, Chair
Ladd Livingston, Treasurer
Ann Lynch, Secretary, CG&PC
Darrell Ross, Counselor and 2000 Conference

Karen Ripley, Memorial Awards Committee
Ken Gibson, Founders Award Committee
Bill Schaupp, 1999 Local Arrangements
Jan Volney, 2001 Conference
Ken Gibson
Ralph Thier, member

Past Chair Lorraine Maclauchlan and Counselors Ed Holsten and Bob Hodgkinson were not present.

The Chair called the meeting to order at 4:15 pm.

The **Minutes of the Final Business Meeting** held on 5 March 1998 were read. Darrel Ross moved to accept the minutes, Ken Gibson seconded, and motion passed. It was agreed to include the 1998 minutes in the 1999 Proceedings.

Status of members was then reported. Two members, Dick Schmidt and Julie Weatherby, have passed away since the last meeting, and appropriate announcements will be made at the Initial Business Meeting. Dick's biography is being prepared by Dave Fellin and will be sent to Ellen Goheen for inclusion in the Proceedings. Donations are being made in their names to the memorial accounts. Dale Bennett will present a memorial statement for Julie, and Barbara Bentz will be asked to make the statement for Dick. The Chair is to ask at the Business Meeting if anyone wishes to make any comments.

COMMITTEE REPORTS

The **Founders Award Committee** Report was presented by Ken Gibson.

The Memorial Scholarship Fundraising Committee Report was presented by Karen Ripley, including comments that there are funds in the account but no action has been taken by the Scholarship Committee. There is a fundraising table at this meeting, and donations are being accepted. It was asked if new members needed to be appointed to the Scholarship Committee, and it was agreed that this was not necessary at this time. Ladd will encourage work from the Committee this year.

Ann reported for the Conference Guideline and Proceedings Committee, including progress on listing the Canadian repositories, reception and revision of materials from the Founders Award Committee for the Web site, and announcement that Colorado State University has agreed to host our Web site. Ann expects the site to be installed early this winter. Ladd reported that the University of Idaho has a copy of each Proceeding, and that he received a request from a non-University library to be on the repository list. Ann said that at least initially she will list herself as the e-mail contact, but that she needs an alternate person for periods of travel and conflict commitments. We agreed that the Secretary could serve in that capacity. A meeting web site for the 2000 meeting will be hosted by Oregon State University by Darrell Ross, with Kathy Sheehan and Bruce Hostettlor assisting.

There were no reports from the History Committee or the Common Names Committee.

The Chair appointed a Nominations Committee of Darrel Ross, Ladd Livingston, and Ann Lynch to find replacements for Secretary and Counselor, replacing Counselor Ed Holsten.

The Treasurer's Report was presented by Ladd Livingston. This year he has been trying to maximize returns to the scholarship monies. The Past and current Chair are supposed to audit the books, and Counselor Darrel Ross was appointed to serve for the Past Chair.

NEW BUSINESS

Item 1. Jan Volney reported on arrangements for the 2001 North American Forest Insect Work Conference. He offered to host that meeting in Calgary, Alberta, at the 2nd NAFIWC in San Antonio, and a motion was passed at Prince George to that effect. Jan reported that Calgary has become very expensive due to growth in the petroleum industry, and costs are astronomical. He has moved the meeting site to Edmonton, where his people a good relationship with a large hotel that does a good job. The hotel can easily handle 350 people. The Edmonton and Calgary airline markets are the same, so you can arrive in one city and leave from the other. The meeting dates are May 2001. The meeting date should be after snow and before the mosquitos. Jan will be looking for volunteers for the Steering Committee, which will be chaired by Jan Volney and John Spence. He has approached the Canadian Forest Service to host the event, which would relieve himself and his people from being liable for costs, etc. His request has to go to the Deputy Minister of Canada for approval, and is in the works with the finance people handling it. Jan thinks that the four Work Conference don't hold separate meetings the years that NAFIWC is held, which is also our impression. Jan has contacted Mallet with the CIFI&DWC, Ron Billings and Doug Allen as past organizers. Announcements will be made in the newsletters of SAF, Canadian Forestry Society, the Entomological Society of America, the Entomological Society of Canada. Ann suggested the Ecological Society of America as well. On funding, Ladd reported that the WFIWC did not provide any funds to support the meeting. Darrel thought that the SFIWC paid the deposits. Jan was not worried on this issue and doesn't expect to need support from us. He does want to organize post-conference tours. Tom asks if he needed any letters from the Work Conference, to which he replied affirmatively.

Item 2. Ralph Thier comes as a member to the Executive Committee to request that the WFIWC recognize Senator Craig for making inquires into the EPA-delayed registration of MCH. He drafted a letter, which Tom will present, and then ask for a motion to call a vote.

Darrell Ross reported that the 20000 meeting will be in Portland OR, 7-11 Feb 00, at the south-side Downtown Marriott on the Willamette River. The Government rate of $89 was agreed to, with Bruce Hostettler doing the negotiations for the work conference. Local conference members wanted to hold the meeting at Embassy Suites, wich is in the building that used to be the old Region 6 Regional Office, but the cost was $130. Charges at the Hilton are $140. The Marriott agreed to $89, and then dropped the rate to $72 when the U.S. dropped the government per diem rates. The hotel was recently remodeled. Portland airfares are reasonable. Ann reported that the Canadians had some difficulties getting approval to come to this meeting because of the high cost. Bill Schaupp has been asked why there is no bug status session at this meeting, and that he replied that that session will be held in February in Portland. Ann suggested putting a suggestion box out, and making sure that the call for meeting suggestions asks for moderator suggestions as well as topics. Bill says also contact any local arrangements people. The Portland Program Committee is yet to be determined.

Tom Eager raised the issue of meeting costs. Many members are excluded from attending because of cost. Ladd and Ann agree it is an important topic for discussion, but that it should wait until the Initial Business meeting. After discussion regarding cost and alternating entomology and pathology hosts, it was mentioned that we host the next meeting, perhaps it needs to be held in Canada, and that it should be run as inexpensively as possible.

Regarding covering meeting expenses for the Founders Awardee, last year, we moved and approved at the Executive Committee Meeting that the speaking recipient will be provided room, banquet ticket, and registration, but not travel costs. Ken said many pathologists complained about the financial agreement and about the entomologist being a pre-arranged banquet speaker. Tom Eager said that no complainants stepped forward. He also reported 182+ early registrants.

Regarding excess funds brought in during the joint meeting: The last time the entomologists and pathologists met jointly excess meeting funds were distributed according to the percentage of registrants, and that is the agreed on procedure.

Bill Schaupp reported that poster boards were a sticky issue, that each conference is being asked to contribute $350 for rental fees, and that an additional $700 by Linda Joyce's project. Ann asked that we send Linda a thank you letter, to which we agreed.

Darrel moved for adjournment at 6:57, seconded by Bill Schaupp, and passed.

WESTERN FOREST INSECT WORK CONFERENCE
50th ANNUAL MEETING
BRECKENRIDGE, COLORADO

Initial Business Meeting
7:30 a.m., 14 September 1999

Chair Tom Eager called the meeting to order at 7:40 am, and tendered greetings to Breckenridge.

Status of Members. The Chair reported the passing of members Dick Schmitz and Julie Weatherby. Memorial comments are available, but will be held for the final business meeting in the interest of time and in the hopes that more members will be present.

Local Arrangements. Bill Schaupp reported difficulty regarding how registration forms were filled out. Different colored dots on name tags indicate which of two tours the attender is assigned to. The two tours will run in opposite directions, and will meet together for lunch. There are in excess of 185 registrants. The Chair addressed thank you comments to Bill Schaupp, reporting that we have Bill to thank for much of the local effort this year.

Secretary Ann Lynch read the **minutes** of the 1998 Final Business meeting. A member noted that Ardin Tagsdad should have been listed as passed away, rather than as retired. Terry Rogers moved that the minutes be accepted, seconded by Terry Rogers, and passed.

The Secretary read the minutes of the 1999 Executive Committee meeting. Ken Gibson moved that the minutes be accepted, seconded by Terry Rogers, and passed.

Ladd Livingston presented the Treasurer's report. This past year he had to find a new bank as the one he had been using closed. This gave him the opportunity to combine some funds. We now have one checking account that serves to cover meeting functions. We continue to have separate accounts for the [McGregor and Memorial Scholarship] accounts. At the time Ladd was establishing new accounts, there was almost $3,000 U.S. in the McGregor fund, and he placed $3,000 in the McGregor C.D. Likewise, he established the Memorial Scholarship C.D. with $6,000. Interest from all accounts, including the C.D.'s, are deposited into a savings account. The savings account represents funds available for scholarships. Ladd has asked the IRS for tax exempt status, and has received no word yet. Chair Tom Eager and Counsellor Darrel Ross will audit the books before the Final Business Meeting, at which time the Chair will ask for an approval motion for the Treasure's Report.
Terry Rogers reported that we are picking up the cost of Mal Furniss' room and banquet, as the Pathologists released his complementary room for someone else.

COMMITTEE REPORTS

The **Memorial Awards Committee** report was presented by Karen Ripley. Approximately $2,700 U.S. is available for scholarship, but the Memorial Scholarship Selection Committee took no action in time for the Breckenridge meeting. Karen hopes that a scholarship can be awarded by the time of the Portland meeting. The Memorial Awards Committee continues to solicit contribution to both funds. They have set up a table near the registration desk, although it's location move during the meeting. At this table, old mugs and Proceedings, historic photos, and other memorabilia are available for sale or donations. Biographical information on Julie Weatherby & Dick Schmitz will be present at the table.

John Schmid asks where memorial contributions are deposited. Ladd replied that they are initially deposited into the checking account, and that these funds are deposited to the respective C.D.'s when the C.D.'s mature. Darrell Ross had questions for the Memorial Scholarship Selection Committee, as he felt that the terms developed by that Committee needed to be approved by the membership before a scholarship is awarded. Karen replied that an effort could be made to develop the terms and make an award. Secretary Ann Lynch clarified this issue by reporting that, according to last year's minutes, the Selection Committee was not given authority to make an award, but to "develop any necessary terms of reference, protocols, plaques, nomination and award procedures", and that the question of making awards was not addressed at that time. Chair Tom Eager said that he would discuss this issue with Lorraine Maclauchlan and Karen Ripley, and will come up with a solution by Friday's Final Business Meeting. Ralph Thier asked if there was to be one or more than one scholarship. Karen replied that the Selection Committee was to determine that.

The **Founders Award Committee** report prepared by Boyd Wickman was presented by Tom Eager. William G.H. Ives, member retired from the Canadian Forestry Service, has been [awarded, nominated?]. Current nominations close on 15 December 1999. Terry Rogers reported that said that Les Safranyic is resigning from committee due to retirement, and needs to be replaced on the committee. Tom Eager will discuss this issue with Boyd Wickman and appoint a replacement. Ken Gibson reiterated that they are accepting nominations until December.

The **Conference Guidelines and Proceedings Committee** report was given by Ann Lynch, who reported that Colorado State University has agreed to host the Western Forest Insect Work Conference web site. Installation of the web site has been delayed because of administrative difficulties in providing access to the University computer from her Forest Service compute system. These difficulties are expected to be resolved shortly, and Ann hopes to install the web site early this winter. This will not be in time for the Portland meeting. A web site for the Portland meeting will be hosted by Oregon State University by Darrell Ross, with assistance from Kathy Sheehan and Bruce Hostetler. Ann reported that she wants to include committee membership, committee history descriptions, charters and terms of reference, and any appropriate forms or documents, for each committee. She indicated that she will be contacting each committee to acquire these documents.

The **WFIWC History Committee** report for April 1998 to September 1999 was submitted by M.M. Furniss and B. E. Wickman. Roy Renkin, Management Biologist for Yellowstone N.P. and M. Furniss are compiling a history of forest insect infestations and control efforts in the Park through 1955. The first reference to forest insects is a 1923 report by J. C. Evenden concerning defoliation by spruce budworm. Outbreaks of other insects occurred in subsequent years and were studied by H. E. Burke and Reginald Balch.

Boyd Wickman has prepared a sequel to our article in the American Entomologist (Winter 1998) on historical photo files of Forest Insect Investigations on the Pacific Slope, 1903-1953. His manuscript, co-authored by M. Furniss and Torgy Torgeson, illustrates and describes the file of the former Portland Forest Insect Lab that is presently located in LaGrande, OR. Torgy has also taken on the task of copying fragile glass negatives onto 35 mm film and has requested funds for cataloging the photos and for improving storage facilities.

The manuscript by M. Furniss entitled: "Walter Julius Buckhorn (1899-1968)-Legendary forest entomologist, not of the classroom kind", has been submitted to American Entomologist. Buck was orphaned at age 12 and his schooling ended with the 8th grade. Yet, he became classified by the Civil service as a professional entomologist on merit alone. This account describes his feats such as climbing and topping 250-foot-tall trees to mark plot corners during the first U.S. aerial spray project involving a forest insect, the hemlock looper, ca. 1932.

Ken Zogas and Ed Holsten, Anchorage Alaska, have published a very useful bibliography containing 638 references to forest insects, diseases, and other biotic agents in Alaska from the first record in 1919 to 1999. Copies of the articles are on file at Ed's office. Besides the entomological and other content, these citations (listed chronologically) show who was stationed there and when. For example, reports by Bill McCambridge, the first forest entomologist stationed in Alaska, appear in 1952, those of his successor, George Downing, appear in 1956.

The **Common Names Committee** report was not available.

At this time, the Chair reported that we have only 8 minutes remaining in time scheduled for the Business Meeting.

OLD BUSINESS

Reports on plans for the 2000 meeting by Darrel Ross, and the 2001 meeting by Jan Volney, were included in previously read minutes for the Executive Committee meeting, and further discussion will be held for the Final Business Meeting.

NEW BUSINESS

New Business will be held for the Final Business Meeting on Friday. This will include the following items:

> Ralph Thier's letter for Senator Craig was read by the Chair. Jan Volney made a motion that we consider this letter, with the motion seconded by Dayle Bennett and tabled until

the Final Business Meeting. The Chair will post the letter for viewing until Friday's meeting.

Nominations and vote for Counselor and Secretary.

Approval of the Treasurer's report.

At 8:30, Terry Rogers moved for adjournment, seconded by John Wenz, and the meeting was adjourned by the Chair.

WESTERN FOREST INSECT WORK CONFERENCE
50th ANNUAL MEETING
BRECKENRIDGE, COLORADO

Final Business Meeting
17 September 1999

*** UNAPPROVED MINUTES ***

Chair Tom Eager called the meeting to order at 10:35 am, and opened the floor for any announcements.

> Barbara Bentz made comments and read a memorial for Dick Schmitz. Dayle Bennet read a memorial for Julie Weatherby. We then observed a minute of silence for our colleagues.

Secretary Ann Lynch read the minutes from the Initial Business Meeting. A motion was made, seconded, and passed to accept the minutes, with the correction noted that Terry Shore, not Terry Rogers, reported Les Safranyik's committee resignation.

A complimentary hotel room was allotted to Mal Furniss as Founders Award recipient, as well as his registration. Other complimentary rooms were awarded to graduate students Zhong Chen and Dan Ryerson. Carroll Williams made a motion to approve this arrangement, seconded by Bill Schaupp, and passed.

Treasurer Ladd Livingston reported that the books were satisfactorily audited and signed off on. The Chair called for a vote on approving the books, which passed unanimously.

Karen Ripley requested on behalf of the Memorial Awards Committee that members please pick up cups, as she doesn't want to carry them home. Ladd Livingston reported that we gained about $315 through the sale of buckles, and $60 and $150 donations for the two funds.

There was no report from the Common Names committee.

Darrel Ross reiterated that the 2000 meeting will be held in Portland on 7-11 February, and that they will begin work soon on the Program. Thanks go to Bruce Hostetler for successful negotiations with the Downtown Marriott, which agreed to the U.S. federal government per diem rate, which is not an easy agreement to obtain in downtown Portland. Any meeting suggestions should be sent to Darrel Ross or Bruce Hostetler. No altitude sickness problems are anticipated, but everyone should bring a raincoat.

Terry Shore reported for Jan Volney on the Edmonton meeting. As presented at the last business meeting, Jan plans to hold the meeting 13-18 May 2001 at the Crown Plaza Hotel. The meeting held there a couple of years ago by the Entomological Society of Canada went very well. John Spence at the University of Alberta will serve as Co-Chair. They have submitted a proposal for support funding; the proposal is currently at the Deputy Ministry level.

OLD BUSINESS

The motion regarding the letter of appreciation for Senator Craig for his assistance in MCH registration was passed.

Ladd Livingston reported for the Nominations Committee. Mark Schultz and Roger Burnside have accepted nominations for Secretary and Councilor, respectively. Ladd called for approval of the nominations, and all were in favor.

Lorrain Maclauchlan reported that she will conduct a conference call of the Scholarship Committee and have a report for the next meeting

NEW BUSINESS

John Schmid talked to Ladd about the cost of plaques, which is $200. The Conference might consider having them done somewhere else for a lower cost. No problems were encountered while having the plaque made in Fort Collins. The basic design of a beetle, moth, and two ponderosa pines is standardized, and we add only the name of the recipient and praises describing their contributions. Ann Lynch and Darrell Ross thought that the price was competitive considering the quality of the plaque. The conference consensus was that the plaque is the responsibility of the Committee, which is free to make production decisions. Ken Gibson said that he will handle this issue as a committee member. The conference consensus was that quality should be a consideration. Ladd made the suggestion that $1 be added to registration fees to cover plaque costs in those years where a plaque is made.

The subject of meeting costs, a matter not discussed at the initial business meeting, was brought up. Several members have commented that costs of attending work conferences is getting out of hand. It was an issue with the local organizers. Four years ago at Rapid City registration was $50. Darrell Ross said airfare and room costs were high for 1998 and 1999, and that is why we're going to Portland next. The Portland organizers worked hard at keeping costs low. The registration fee will be similar, as people don't seem to have much trouble with it. Bill Schaupp, as the entomologists' representative on the Breckenridge local committee, said that he observed very different philosophies between the two conferences, and that he had difficulty championing our philosophy of keeping costs low in order to foster attendance. Costs at Albuquerque, the last joint meeting hosted by the entomologists, were less. There were comments and strong feeling that retirees and students be given a lower registration fee. Ladd Livinston said that we already allow a 50% discount; Ann Lynch thought not. They will both look into it.

Carrol Williams supports lower cost for students and retirees, holding the meetings in attractive venues, and the ability to go on field trips. He wishes that the meeting wasn't in February because a later date would facilitate a field trip and driving instead of flying. He suggests that we address the problem with air fares by meeting at places we can drive too. Darrell commented that with regards to Portland weather, there is no effective difference between February and March. Carroll pressed for meeting in late March or early April. Barb Bentz commented that they selected Jackson in order to provide a smaller venue where people can walk from the hotel without getting lost in a large city, as many members prefer smaller venues. Bill Schaupp clarified that a number of conference members have commented appreciably on the current venue regarding location. Karen Ripley commented that local people always think these issues through very well, and that a lot of effort is involved; she suggests a "rider board" to for people looking for someone to share their room. Ken Gibson said that at one Work Conference they opted not to have a banquet. Darrell and Bill indicated that at many hotels there is no charge for meeting rooms if you arrange a number of meals and guarantee a number of lodging guests at the hotel, otherwise you have to pay for the meeting rooms. Bill reported that they held a luncheon rather than a banquet in Albuquerque, and reminded us that we need to provide a venue for the Founders Award speech. Darrell said that they are considering including the Founders recipient talk in a plenary session. They are also considering having a combined meal and mixer event, rather than a sit down meal. Ladd said that break refreshments were exceptions but probably very expensive. Carroll says that there are tradeoffs, that sit-down meals can be very important, given our group's dynamics and needs to meet with old contacts and make new ones. Sit down meals bring an aura of togetherness that is not present in many other meetings; this is the one of the distinguishing features of the Work Conference meetings - it is a time for us to get together and mingle.

Roy Mask was called on to discuss the possibility of meeting in a campus setting. This really adds to Barb's earlier comments on keeping the group together in a smaller venue. A number of universities can provide field camps or dormatories. Colorado State University's field camp is designed for conferences, and you are in a retreat atmosphere away from town. Other universities have similar arrangements. Ken Gibson said that the 1981 Bend meeting was at a school; the arrangements were adequate but not elegant. Carroll Williams had a similar experience at a school in Switzerland: an isolated, cohesive setting with a cafeteria with a cook, during the off-season in the Alps.

Carroll wants us to hold a meeting in Mexico, preferably sometime soon. He encourages us to think along those lines. Tom Eager and Mike Wagner have been speaking with Jaime Villa Castillo on this. They need to work out some procedural difficulties.
Bill Schaupp was recognized for being involved in organizing two meetings within the last four years, and Ann Lynch for two-term service as Secretary.

John Schmid asked about the status of the Rapid City Proceedings. Ann replied that they are compiled but that she is having difficulty getting the group photos printed properly in Flagstaff. Ellen Goheen indicated that she will be strict on her Proceedings.

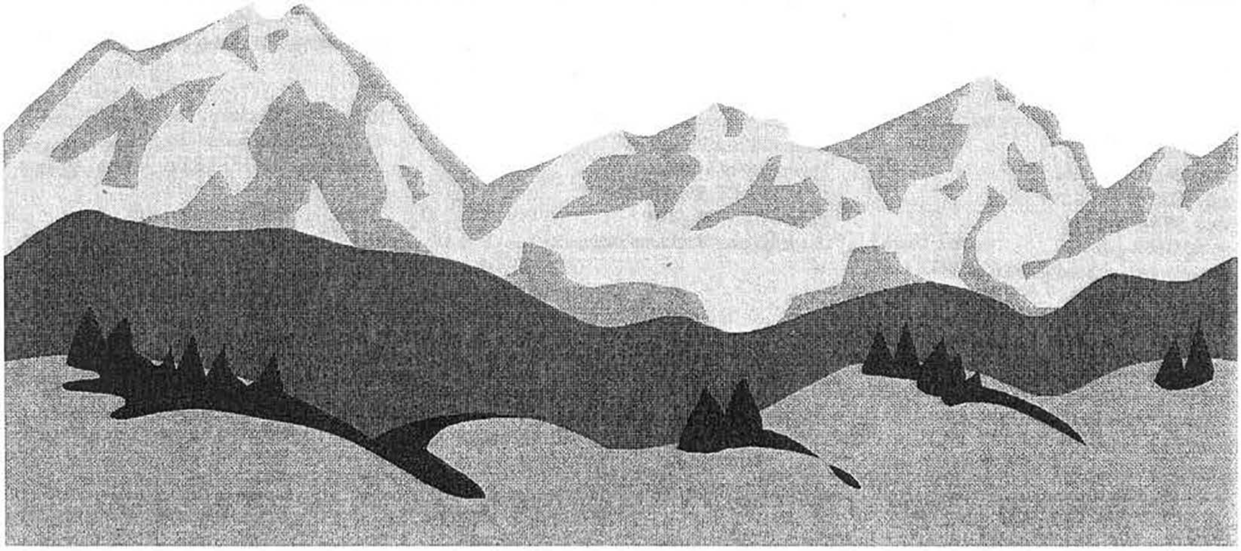
Comments were made on low attendance at many of the Final Business Meetings. Darrel Ross suggests not waiting to the end of the conference to hold it. Ann pleaded for scheduling the Executive Committee Meeting so that it ends at least an hour before the mixer, and that the Initial Business Meeting can't be at 7:30 the next morning. It is very difficult for the Secretary to prepare Executive Committee business in time for the Initial Business Meeting.

Regarding conference attendance, Ellen doesn't yet have a breakdown of pathologists vs. entomologists. Tom Eagar said that the breakdown is very important in settling financial matters.

Ken Gibson asked about the next meeting, and when we will meet in Mexico? This matter was tabled until February, where we will be looking for an invitation from the Mexicans. Ken said that Region 1 will tender an invitation if one is not received from Mexico. Ken made a motion to that effect, seconded by Carrol Williams, and passed. During discussion, Eric Smith reminded us that the Mexicans expressed interest in hosting the North American Forest Insect Work Conference, so there is interest from Mexico. Groundwork for a Mexico meeting has to be laid out further in advance then we often operate in order for government employees to obtain permission to go. Ann said that if we are going to meet in Mexico then at least one Counselor elected in Portland should be a Mexican, as should be the next Chair.

Bill Schaupp moved for adjournment, seconded by Ken Gibson, and passed.

WIFDWC Membership List



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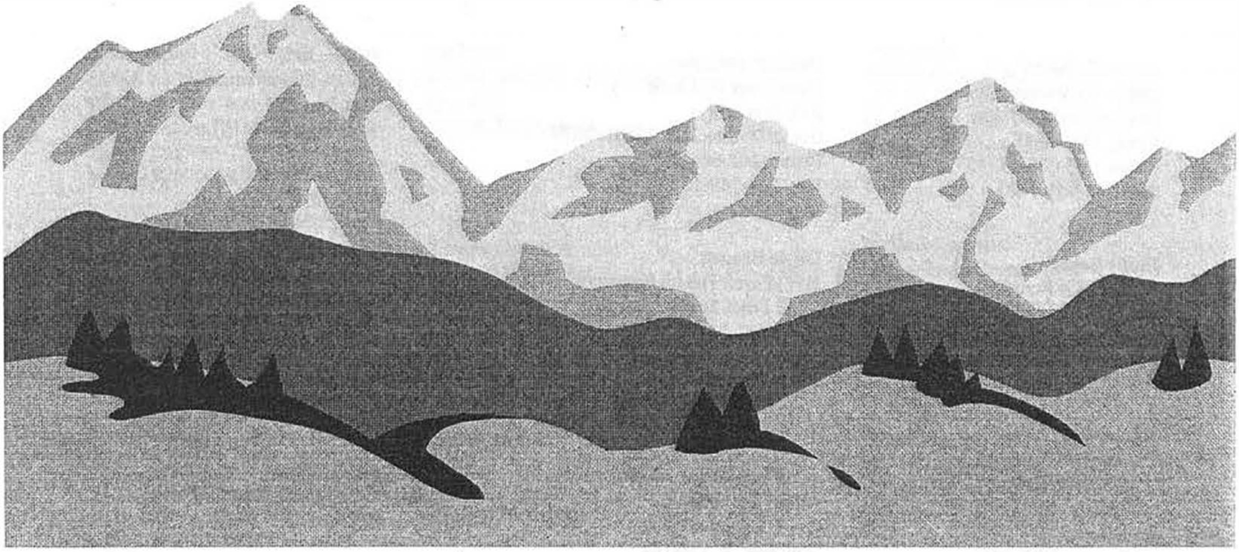

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